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HELICOPTER SECONDARY STRUCTURES RELIABILITY AND MAINTAINABILITY INVESTIGATION

Patrick J. Cunningham, et al

Kaman Aerospace Corporation

Prepared for:

Army Air Mobility Research and Development Laboratory

January 1974

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13. ABSTRACT

The purpose of this report is to define new or modified design/test criteria which, when applied to the design of new helicopter secondary structures, will enhance their maintainability and reliability. Criteria pertinent to secondary structures were abstracted from existing literature. Kaman's data on secondary structures were analyzed, and components exhibiting high maintenance and failure rates were identified. A check was made of the correlation between existing criteria and experienced failure modes, and new criteria that had potential for eliminating or reducing the experienced failures or maintenance actions were defined. Two components (the pilot rescue door and fuselage box steps) were selected for testing in current design configuration to verify field experience, for modification in accordance with new criteria, and for retesting to verify the efficacy of such new criteria. In this test program, the effects of corrosion were ignored. The door test in current design configuration showed a marked improvement over the current design, thus verifying the effectiveness of the application of new criteria. The test program on the fuselage box steps was inconclusive since no failures were induced in either the current or the modified components. A failure mode and effects analysis was performed on the selected components. The analyst had access to the design drawings and knowledge of the components' functions but not to their maintenance history. The results of this analysis checked reasonably well with the field experience on the components, considering the lack of historical data upon which to base predictions. The implementation of the proposed new criteria, in conjunction with failure mode and effects analyses, applied to the design of new secondary structures shows good potential for enhancing the maintainability and reliability of future generations of such structures.

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DEPARTMENT OF THE ARMY
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This report, which was prepared by the Kaman Aerospace Corporation under the terms of Contract DAAJ02-72-C-0069, presents the results of one of two parallel efforts to investigate and develop new or modified design and test criteria to improve the reliability and maintainability (R&M) of helicopter secondary structures.

The objectives of this contractual effort were (1) to review all existing fixed-wing and rotary-wing aircraft standards and specifications for areas applicable to secondary structures and (2) to perform a failure mode analysis of the Kaman H-2 helicopter secondary structures to identify areas of deficiencies attributable to inadequacies of standards and specifications and to propose new or modified design and test criteria for helicopter secondary structures.

In general, the recommendations presented in this initial effort offer a reasonable approach to improving the R&M of helicopter secondary structures.

The technical monitors for this contract were Major Andrew E. Gilewicz and Mr. Thomas E. Condon of the Military Operations Technology Division of this directorate.

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HELICOPTER SECONDARY STRUCTURES RELIABILITY AND MAINTAINABILITY INVESTIGATION

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SUMMARY

The purpose of this report is to define new or modified design/test criteria which, when applied to the design of new helicopter secondary structures, will enhance their maintainability and reliability.

In pursuance of this aim, criteria pertinent to secondary structures were abstracted from existing literature. The contractor's data on secondary structures were analyzed, and components exhibiting high maintenance and failure rates were identified. A correlation check was performed between existing criteria and experienced failure modes, and new criteria were defined which had potential for eliminating or reducing the experienced failures or maintenance actions.

Based on the review of the contractor's data, two components were selected for testing in current design configuration to verify field experience, for modification in accordance with new criteria, and for retesting to verify the efficacy of such new criteria. In this test verification program, the effects of corrosion were ignored. The components selected were the pilot rescue door and fuselage box steps.

The door test consisted of 250 hours of vibration and 5,000 open/close cycles for current and modified designs. The current design test verified the major operational field failures. The modified design test showed a marked improvement over the current design component, and thus verified the effectiveness of the application of new criteria.

The box step test consisted of 40,000 applications of loading on the step area. Both current and modified design steps were subjected to three complete tests, each one at a higher load level than the preceding one. No failures were induced in either of the configurations; consequently this component test program was inconclusive.

A failure mode and effects analysis was performed on the selected components. The analyst had access to the design drawings and knowledge of the components' functions but not to their maintenance history. The results of this analysis checked reasonably well with the field experience on the components considering the deprivation of historical data upon which to base predictions.

The implementation of the proposed new criteria, in conjunction with failure mode and effects analyses, applied to the design of new secondary structures shows good potential for enhancing the maintainability and reliability of future generations of such structures.

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INTRODUCTION

Reliability and Maintainability (R&M) of helicopter components has always involved a trade-off with the elements of cost and performance. In fixed-cost contracts, R&M improvements have normally been obtained with some sacrifice of performance. A small improvement in R&M has generally involved a large expenditure of man-hours in the design and planning stages of the contract. As a result, most efforts in R&M up-grading have been concentrated on the high-cost components which have major impact on aircraft safety, cost and future maintenance. Typical of such components are the rotor and associated components, transmission and engine mounts, landing gears, and certain portions of prime airframe.

Historically, much less effort has been expended on other areas of the helicopter. Generally, problems arising in these more lightly considered areas of the helicopter do not present major problems in safety, maintenance or cost when considered individually. In sum, however, the aggregate man-hours required to maintain these components can mount at a startling rate.

The foregoing statements are particularly applicable to those components designated as "secondary structures". A survey conducted by the U.S. Army indicated that the upkeep of secondary structures accounted for 25%-30% of all maintenance man-hours expended during the survey period. This is, of course, an unreasonable expenditure of effort on structures which theoretically are not essential to flight operation of the helicopter.

In an attempt to obviate this problem, the U.S. Army Air Mobility Research and Development Laboratory at Fort Eustis awarded a contract to investigate the reliability and maintainability of helicopter secondary structures.

The objective of the program initiated by this contract is to determine the feasibility of defining new or revised design/test criteria to be applied to new designs to improve the reliability and maintainability of helicopter secondary structures.

The scope of work authorized in this contract may be briefly stated as follows:

1. Review all existing specifications and standards for criteria applicable to the design of helicopter secondary structures.

2. Review and analyze contractor's operational and overhaul maintenance data of secondary structures for high maintenance and failure rates and perform a failure mode analysis on those components which exhibit particularly high rates.

3. Compare existing design criteria with the modes of failure experienced in the field. From this comparison, define new or modified design and test criteria which have potential for eliminating or reducing the failures and maintenance actions uncovered in the operations analysis.

4. Select several candidate secondary structures to which new or modified design and testing criteria could be applied for verification. These structures will be chosen as a result of the operational analysis performed in (2) above. The structures will be tested in their existing design configuration and also in a functionally identical modified design configuration.

5. Conduct reliability analyses (Failure Mode and Effect Analyses or FMEA) on current design secondary structures to determine whether the analyses correlate with actual service experience on the selected components.

This report addresses itself to these items.

LITERATURE SEARCH AND EVALUATION

REVIEW OF EXISTING SPECIFICATIONS

Presented in this section are the criteria relating to secondary structures which were culled from existing specifications.

For convenience, a summary of these criteria is also included. All applicable specifications which might contain references to, or criteria for, the design of secondary structures were perused and the relevant data extracted. It should be pointed out at this time that although the term "secondary structures" has been used in the aircraft industry for many years and everyone is familiar with its meaning and implications, nowhere in the specifications were any structural components defined as "secondary".

References 1 through 25 comprise the specifications perused in this search. The various specifications tended to iterate the same criteria with just minor variations in wording, and apart from cargo doors and radomes no attempt is made to define loading (spectra) criteria.

MIL-A-008861A (USAF)

3.18 Deformation of doors, cowlings, locks, and fasteners. Doors, locking mechanisms, such as landing gear up-locks and down-locks, and cowling fasteners shall not deflect adversely from their intended positions at loads up to limit load for each loading condition for which limit loads are specified. Unlocking, unlatching, or release of coverings, and unlocking or unfastening of mechanisms shall not occur at loads up to and including design ultimate for loading conditions for which limit or design ultimate loads are specified. Doors, other than passenger, cargo, or baggage doors; cowling; and other coverings shall remain in place under design ultimate flight loads if 10 percent of the fasteners are unfastened or if one quick-release fastener selected at random on each side of a door or panel secured by these fasteners is unfastened.

MIL-A-008865A(USAF)

3.8.2 Cargo doors and radomes. The cargo loading doors, entrance doors, radomes, etc., shall be in their open position and any intermediate positions specified in the detail or end item specification and shall be designed for the loads resulting from a 35-knot steady wind and 70-knot gusts from any horizontal direction. The doors

and radome actuating mechanisms shall include design for operation during 35-knot steady wind in any horizontal direction combined with a vertical load factor of 1.0 ± 0.5g and a horizontal load factor (in the most critical direction) of ± 0.5g.

MIL-A-008867A(USAF)

3.4.5.6 Deformation of doors, cowlings, locks, and fasteners. During structural tests, it shall be demonstrated that doors, cowlings, movable and removable coverings, and items of mechanical equipment, such as landing gears, remain in their intended positions and do not gap at limit load to the extent that they would induce deleterious aerodynamic effects or interfere with the operation of some other component.

MIL-S-8698(ASG)

3.1.3.3 Doors, cowling, locks, and fasteners. Doors, cowling, locks, and fasteners, including landing gear up and down locks and cowling fasteners, shall not deflect from their intended positions in such manner as to permit unwanted opening, closing, or release of coverings or unlocking or unfastening of mechanisms at all loads up to ultimate.

MIL-T-8679

3.1.10.7 Deformation of doors, cowlings, locks, and fasteners. It shall be shown during structural tests that doors, cowling, movable and removable coverings, and items of mechanical equipment, such as landing gears, remain in their intended positions consistent with specified structural design requirements.

3.2.9.3.4 Doors, fairings, and removable sections. Ultimate load tests shall be conducted for those items not previously tested for critical flight conditions.

AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT PART 27

27.1193 Cowling and engine compartment covering.

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(b) There must be means for rapid and complete drainage of each part of the cowling or engine compartment in the normal ground and flight attitudes.

(c) No drain may discharge where it might cause a fire hazard.
(d) Each cowling and engine compartment covering must be at least fire resistant.
(e) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

27.1194 Other surfaces. All surfaces aft of and near powerplant compartments, other than tail surfaces not subject to heat, flames, or sparks emanating from a powerplant compartment, must be at least fire resistant.

SD-24J, 21 JANUARY 1961

3.11.6 Cowling and Cowl Flaps. Cowling and cowl flaps include engine cowl, accessory compartment cowl, and cowl flaps.

3.11.6.1 Cowling Design. Cowling shall be readily removable in part or entirely to permit access to the powerplant. Removable p :s of the cowling shall be of size and shape convenient to handle and shall be arranged to prevent loss overboard. Reciprocating-engine cowling shall provide a tight seal with the baffles furnished with the engine. The bottom of the cowling, forward of the firewall for reciprocating engines, shall be self-draining. All cowling shall be ventilated to prevent accumulation of gases, to ensure proper cooling of the engine and its vibration isolators, and to prevent high temperatures in the engine compartment, accessory compartment, or in inhabited spaces. Vents and joints in cowling shall be located out of the path of the exhaust gases, and joints shall be flametight. Cowling in the region of the exhaust outlet which might be subjected to exhaust flame shall be of corrosion-resistant steel, or other equivalent heat-resistant alloy. Cowling shall permit the maximum engine deflections without overstressing the cowling. Cowling shall not interfere with gunsights or parts of the power plant. Recessed pockets shall be provided in the cowling of seaplanes to serve as receptacles for loose materials normally handled during power plant inspection and maintenance.

3.11.6.2 Cowling attachment (reciprocating engines). Cowling shall be securely attached to the engine or to the airplane structure, but not both at the same time if vibration isolators are employed. Cowling, fastenings, and

supports shall provide minimum drag, maximum protection from the weather for the engine, protection to the crew from oil and fire in the engine compartment, and minimum interference with vision ahead and alongside. Metal-to-metal contact in all areas subject to fretting or wear due to flexing and engine vibration shall be insulated, using materials which are inert from a corrosion standpoint and resistant to heat, lubricants, cleaning solvents, etc. Where practicable, the rubbing strips shall be fastened to the fixed members rather than the removable members. Particular attention shall be given to the prevention of rotary and fore-and-aft movement of the cowling and to the prevention of failure due to expansion of the engine.

3.11.6.3 Cowl flaps (reciprocating engines). Cowl flaps shall have minimum lost motion in operating the interconnecting parts, considering wear and vibration incident to service. Wear shall be localized in the hinge-pins or other parts easily replaceable. When cowl flaps are not readily visible to the proper member of the crew, an electrical position indicator (or mechanical indicator when approved by BuWeps) shall be provided to show the position of the flaps.

3.11.7 Integral engine working platforms. Consideration shall be given to providing integral engine working platforms for engine maintenance which cannot be readily performed from the ground (deck) or airplane surfaces.

SD-24J, VOL II, 27 JUNE 1963

3.11.6 Cowling. Cowling includes engine cowl and accessory compartment cowl.

3.11.6.1 Cowling Design. Cowling shall be readily removable in sections or may be hinged to permit access to the power plant. Removable sections of the cowling shall be of size and shape convenient to handle and shall be arranged to prevent loss overboard. All cowling shall be ventilated to prevent accumulation of gases in the engine compartment, accessory compartment, or inhabited spaces. Vents and joints in cowling shall be located out of the path of the exhaust gases, and joints shall be flame-tight. Cowling in the region of the exhaust outlet and all portions of the cowling which might be subjected to exhaust gas impingement and to exhaust flames in the event of an exhaust system failure shall be corrosion-resistant steel, titanium or other equivalent heat-

resistant alloy material. Cowling shall permit the maximum engine deflections without overstressing the cowling. Cowling shall not interfere with any parts of the engine or its installation.

3.11.6.2 Cowling Attachment (reciprocating engines). Cowling shall be securely attached to the engine or to the rotary-wing aircraft structure, but not to both at the same time. Cowling fasteners and supports shall provide minimum drag, maximum protection from the weather for the engine, protection to the crew from oil and fire in the engine compartment, and minimum interference with vision ahead and alongside. Metal-to-metal contact in all areas subject to fretting or wear due to flexing and engine vibration shall be insulated, using materials which are inert from a corrosion standpoint and resistant to heat, lubricants, cleaning solvents, etc. Where practicable, the rubbing strips shall be fastened to the fixed members rather than to the removable members. Particular attention shall be given to the prevention of unplanned rotary and fore-and-aft movement of the cowling and to the prevention of failure due to expansion of the engine.

3.11.7 Integral Working Platforms. Integral engine working platforms, for engine maintenance which cannot be readily performed from the ground (deck), shall be provided.

AFSC DH 2-1, DN 3A3
CHAP 3 - DETAIL DESIGN, SECT 3A - SUBSTRUCTURES

8. Cowling. Cowling is covering which is not an integral part of the aircraft structure and is removable in pieces or hinged to permit access to the interior of the aircraft. Design individual pieces for convenient removal and installation by one man. Cowling panels may be of the detachable or hinged types. Provide detachable types with approved cowling fasteners. Use MS20257 continuous type hinges only when the hinge line is straight and not over 2 ft long, and the joint does not require disassembly. Do not consider these as flush type hinges. Spot welding may be used in the fabrication of cowling, subject to structural and welding requirements.

8.2 Joints. Design cowling joints to minimize air leaks due to the difference in air pressure between the inside and outside of the cowling. Do not overlap joints unless the inside element is much less frequently removed than the outer element.

8.3 Strength. Design cowling and its supporting structures to the strength requirements of MIL-A-8865. Ensure that detachable pieces do not distort enough to be permanently deformed by normal handling. Design all cowling to avoid stress concentrations and to withstand anticipated vibratory and air loads or critical combinations thereof. Attach hinged panels with hinges and fasteners of strength adequate to withstand all flight and wind loads. Design the cowling panels and component parts of the cowling assembly so that no localized resonances are possible.

8.4 Engine Cowling. In addition to the requirements previously set forth, design engine cowlings to conform to the following requirements:

a. Use rivet heads flush on the outside on all riveted joints exposed to the airstream.
b. Minimize vibration difficulties associated with engine cowling by supporting the cowling independently of the engine. The cowling may be supported both by the engine mount structure and by the aircraft structure provided effective vibration isolators are interposed between the power plant and the engine mount structure; ensure that seals between the engine cooling baffles and the cowling are sufficiently flexible or flexibly mounted to preclude transmission of engine vibration into the cowling structure. Vibration isolators supporting the engine cowling are subject to the same temperature requirements that are applicable to engine mount vibration isolators.
c. Design ducting to avoid stress concentrations which might otherwise result in fatigue failures.
d. Design all cowling to allow for expansion of engines without straining of supports and fasteners or displaying wrinkles.
e. Design cowling to confine possible fires to the engine compartment.
f. Do not modify engines for the attachment of cowling supports.

8.5 Cowling Fasteners. Devices such as cables, turnbuckles, bolts, machine screws, wing nuts, and trunk clasps, which project into the airstream and prevent a smooth contour or which require an appreciable amount of time to loosen or tighten, are not satisfactory cowling fasteners. Do not use these without special permission from the procuring activity. Design and install ring cowling fasteners to provide means for positive locking and adequate take-up and adjustment of the cowling. Make

fasteners accessible to permit quick removal of the cowling. Ensure that quick-acting fasteners used on the external surfaces of aircraft to attach cowling, access doors, etc., are flush with the surface when the fasteners are locked. Use panel fasteners conforming to MIL-F-5591 on relatively flat flexible cowling, inspection doors, quick-detachable plates, etc. Base the size of fasteners and their spacing in the cowling on their strength values, as listed in MIL-F-5591, and on the loads to which they are subjected by the cowling. Toggle linkage, flush-type, quick-acting fasteners which meet safety and strength requirements are permissible on hinged cowling. Use quick-acting flush fasteners of the trunk or latch type on large, stiff cowling of compound curvature. Do not use quick-acting fasteners which depend upon spring-loaded tabs or levers for locking and which may be unlocked or unsafetied by shock or positive or negative blast pressures on fighter or bomber aircraft which are potential atomic weapon carriers. To simplify maintenance, incorporate bolts or screws of equal length on each panel secured with threaded fasteners having the same diameter.

SD-24K VOL II, 6 DECEMBER 1971

3.7.1.8 Windows and Ports. To the extent that thermal considerations permit (see 3.2.2.1.9), windows and ports shall be constructed of monolithic stretched acrylic plastic. The selection of other constructions requires NAVAIR approval. Windows and ports shall be watertight and mounted so that they may be replaced, preferably from the inside, without mutilation of the fuselage and so that they will not fail due to applied loads, distortion, or vibration of the aircraft in service. Windows and ports shall be capable of being readily opened for purposes of ventilation, refueling, etc., when specified in the detail specification. Window guards shall be provided in series CH and UH aircraft to protect windows from damage by cargo. The guards shall permit cleaning of the windows from inside.

SD-24J VOL II, 27 JUNE 1963

3.7.1.3.1.1 Cockpit and Cabin Enclosures. Provision shall be made to protect weather seals from damage as a result of normal maintenance activities and from normal entrance and egress of the crew.

3.7.1.3.1.1.1 Cockpit and Cabin Enclosures. Means shall be provided to readily jettison the movable sections from the rotary-wing aircraft from both inside and outside the

cockpit in the event of a crash to facilitate crew exit and rescue operations.

Movable sections shall be readily jettisonable in flight and shall not contact the rotors or horizontal tail surfaces. Instantaneous actuation is desired.

Movable sections of the sliding type shall positively lock in the fully open and fully closed positions,and the locking provision shall withstand 20g crash deceleration loads. Provision shall be made at the fully open and fully closed positions of movable sections to protect the tracks and rollers from failure due to wear caused by vibration.

3.7.1.6 Doors and Hatches. All doors and hatches shall be provided with a seal to prevent entrance of sand, dirt or spray. Joints of doors and hatches shall be smooth with no gaps to cause a breakdown of airflow. Latches, hinges and locks shall be of corrosion-resistant materials or adequately protected against corrosion and shall have positive means for lubrication. Single, simple-action door latches shall be used.

SD-24K VOL II, 6 DECEMBER 1971

3.7.1.6 Doors and Hatches. All doors and hatches shall be provided with a seal to prevent entrance of sand, dirt or spray. Seals shall be positively retained by methods other than or in addition to adhesive bonding and shall be easily removed and replaced.

3.7.1.7.2 Emergency Manual Egress Systems. In addition to being jettisonable, all escape hatches and doors that can be opened in flight shall have a hold-open lock of sufficient strength to prevent the closing of the hatch from loads experienced during a survivable crash or ditching. A deceleration force of 40g shall be considered survivable.

References from both SD-24J and SD-24K are quoted to show that either 20g or 40g could be interpreted as a crash criterion for door structures.

SUMMARY OF EXISTING SPECIFICATIONS

A summary of existing criteria applicable to the design of secondary structures may be presented as follows:

(1) Structures shall not deform excessively under design limit loads. Large gaps shall not be created between adjoining structural components.

(2) Fasteners shall be such that removable structural components shall not unlatch under design limit loads. Ideally all fasteners shall be of same size, type and length.

(3) Removable structural components shall be capable of withstanding "normal" handling loads.

(4) Movable sections of the sliding type shall positively lock in the fully open and fully closed positions, and the locking provisions shall withstand crash deceleration loads.* Provision shall be made at the fully open and fully closed positions of movable sections to protect the tracks and rollers from failure due to wear caused by vibration.

(5) Seals shall be positively retained by methods other than or in addition to adhesive bonding and shall be easily removed and replaced. Seals located at door edges should not suffer damage as a result of normal personnel ingress and egress.

(6) Emergency releases for escape exits shall be operable by a force not exceeding 30 pounds.

(7) Cargo loading doors, entrance doors, radomes, etc., shall be in their open and any intermediate positions specified in the detail or end item specification and shall be designed for the loads resulting from a 35-knot steady wind and 70-knot gusts from any horizontal direction. The doors and radome actuating mechanism shall include design for operation during 35-knot steady wind in any horizontal direction combined with a vertical load factor of $1.0 \pm 0.5g$ and a horizontal

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* Crash deceleration loads are defined as 20g or 40g, Reference SD-24K Vol II, Paras. 3.7.1.3.1.1.1 and 3.7.1.7.2.

load factor (in the most critical direction) of $\pm$ 0.5g.

The above items briefly present all of the data which can be extracted from existing specifications.

CRITIQUE OF EXISTING SPECIFICATIONS

Reference to the Summary of Existing Criteria discloses the paucity of relevant criteria which are available for use in the design stages of secondary structures. Although the terms primary structure and secondary structure have been in common use in the aircraft industry for many years and although all appropriate governmental agencies are thoroughly familiar with their definitions, still, none of the official technical specification documents take cognizance of the items.

Again, in the specifications, when mention is made of structural components which are obviously in the secondary structure category, with only a few exceptions, no reference is made to loading conditions applicable to such components. These exceptions are encountered in MIL-A-8865 where air-loadings are specified for cargo doors and radomes and in SD-24K (Vol II) where it is specified that escape hatches and doors which can be opened in flight shall have a hold-open lock of sufficient strength to prevent the closing of such hatches from loads experienced in a 40g crash or ditching.

Most references in the specifications are to items such as engine cowlings, and the concern for these items centers on deflections and methods of edge attachments. Items of secondary structure which in their intended usage are quite heavily loaded, such as work platforms, are completely glossed over. It is, of course, understood that any component of secondary structure which, in its nonoperative position, forms part of the exterior envelope of the aircraft must be capable of sustaining the loadings induced throughout the flight regime. Also, in some instances, the components must not come loose under crash conditions. However, again considering work platforms, due to the methods of retention in the stowed configuration, these gross loading conditions may be much less severe than the loads imposed on such a platform in its operating position. No mention is made of the weight of a man to be considered on a work platform or the design load factor to be used therewith. These same comments are also applicable to steps and walkways.

Specification SD-24K mentions in relation to sliding doors, "Provision shall be made at the fully open and fully closed positions of movable sections to protect the tracks and rollers from failure due to wear caused by vibration". This simple statement encompasses a very laudable object and a very difficult task. So long as any clearance envelope exists between the contours of the tracks and rollers, then, in a vibratory environment, relative motion and subsequent wear will occur. It may be possible to reduce the magnitude of this problem, but it is more than likely that the required expenditure of time and money will not yield proportionate benefits in field service.

In summation, with regard to specific design criteria applicable to secondary structures, the existing specifications are uninformative and vague. The proposed new criteria will hopefully remedy this defect.

As a consequence of the lack of well defined criteria in existing specifications, the responsibility for definition has historically devolved upon the individual design companies. In virtually all aircraft companies the resultant in-house definitions of criteria and load spectra have tended to produce secondary structures which are adequate within a rather narrow spectrum of loading. Examples of this would be items such as doors, work platforms, walkways and steps which are demonstrably adequate for the design-visualized loadings but which fail in service because the effects of repeated loadings had not been considered. Very often this has resulted in the production of lightweight secondary structures which are adequate for the narrow range of chosen criteria but on which very little effort has been expended to enhance reliability and maintainability.

ANALYSIS OF OPERATIONAL AND OVERHAUL MAINTENANCE DATA

In the appendix are pages containing data relevant to secondary structures abstracted from Reference 26. Reference 26 is a study performed under contract to the U.S. Navy. The purpose of the study was to analyze historical records on the H-2 helicopter as a basis for identifying existing or potential problem areas in Fleet or Progressive Aircraft Rework (PAR) maintenance of the H-2 airframe. Company inspection records prepared during PAR on the H-2 and Navy supplied 3-M data provided the basic source data for the survey. These data were processed and analyzed to determine areas of frequent repair or parts replacements, reports of excessive corrosion treatments and items contributing significantly to unscheduled maintenance

man-hours, downtime and PAR costs. This study concerns itself only with those components on the helicopter which exist below the roof-line. Consequently, above-roof items such as engine cowlings and work platforms are not reported upon. However, company and Navy maintenance records indicate that no significant problems exist on those secondary structural components above the roof-line.

Perusal of the abstracted pages in the appendix shows that the data presented are extremely comprehensive.

Each page deals with only one area of concern, and for each discrete area the following data are available:

1. Nature of discrepancy.
2. Contributing factors.
3. Percentage of PAR's on which discrepancies are found and average number of discrepancies per PAR.
4. Primary failure modes and dispositions.
5. Field history of component with five-high failure causes.
6. Recommendations.

This is of course a rather comprehensive analysis of the operational and maintenance history of these secondary structural components and enables one to rapidly isolate those components which have been particularly troublesome.

COMPARISON OF EXISTING DESIGN CRITERIA WITH FAILURE MODES IN THE FIELD

Perusal of the operational and overhaul maintenance data in the appendix shows that the following modes of failure are the most common encountered in field service:

1. Broken/cracked
2. Worn
3. Deteriorated
4. Misaligned/misadjusted
5. Missing hardware
6. Corrosion

In this enumeration of failure modes, corrosion is listed last, although in the actual data listing it places high among failure causes on the surveyed items. This ranking of corrosion at the bottom of the list is deliberate since corrosion failures cannot be prevented by criteria definitions. Corrosion is obviated by proper choice of materials singly or in close contact, protective treatments, and exercise of design skills in prevention of moisture entrapment and sealing techniques.

Again, none of the existing criteria address themselves to failure modes No. 3 or No. 4. Deterioration is a time/environment dependent condition and can be lessened by judicious choice of materials. Misalignment or misadjustment of components in the field generally results from lack of training, misunderstanding or carelessness, and no design criteria could ever cover these eventualities.

There are no existing secondary structure criteria whose application would prevent the loss of hardware in the field (i.e., failure mode No. 5). However, in primary structural components and in particular in control linkages, it is customary to specify that removable fasteners be installed with the head up to prevent loss of the fastener following disengagement of the nut. If this practice was followed generally throughout the helicopter and not only in critical primary structure applications, it could help abate the problem of missing hardware.

This leaves the failure categories of broken/cracked and worn for consideration. As is pointed out in the Critique of Existing Specifications, there is only one reference to concern for

wear and that relates specifically to roller/track combinations for movable sections. However, this statement, that provision shall be made to protect rollers and tracks from failure due to wear caused by vibration, is so general as to be useless. Nothing in existing criteria could have been applied to forestall or obviate the problem of worn components in the field.

Finally, there is the broken/cracked category of failure mode. None of the failures which were recorded in this category could be identified as being caused by static or pure overload conditions. Instead, the attributed causes of failure were vibration or fatigue, impact, or abuse. Once again, no existing formalized design criteria are applicable to preventing this type of failure.

In summary, none of the failure modes experienced in the field can be attributed to lack of application or mis-application of any of the existing design criteria presently available in military specifications and applicable to the design of secondary structures. This highlights the general inadequacy of the available criteria.

PROPOSED NEW CRITERIA

Criteria were defined which would be applicable in the design of new secondary structure components. All criteria which are considered feasible and practicable are presented, including those already in use (although not presently formalized) at Kaman Aerospace Corporation and probably most other helicopter design companies.

In the definition of these proposed new criteria, effort was expended to correct the general shortcomings found in existing criteria. These shortcomings are, in general, a lack of definition in loading conditions and a vague generality of intent where secondary structures are involved. These faults are discussed in more detail in the sections dealing with criticism of existing specifications and comparison of field failure modes with existing criteria.

These criteria are a distillation of the experiences and judgements of design, reliability and maintenance personnel. In relation to maintenance personnel, many useful thoughts were garnered by inviting their candid comments on present design structures. Contributions were also made by service engineering personnel. These are, of course, the people who must live in daily contact with the designs produced by their company and consequently are conversant with all reported problems from field use.

The following criteria are proposed as being applicable to new designs for secondary structures:

PROPOSED NEW DESIGN CRITERIA

(1) Secondary structural components such as work platforms, auxiliary walkways, steps, and any similar man-loaded item shall be capable of sustaining a 200-lb man (i.e., the U.S. Army's 95th percentile man) in conjunction with a limit load factor of 2.0. A 200-lb load shall be considered to be applied for 25,000 cycles to ensure adequate endurance life of items such as hinges, support lugs and backup structures.

(2) Removable secondary structural items such as cowlings and other panels of appreciable size shall be capable of withstanding a drop from "X" feet in all positions without sustaining deformations which would result in installation difficulties or degradation of intended function.

Definition of "X": For items such as engine cowlings and work platforms it would not be unreasonable to expect them to be capable of being dropped from their intended locations on the airframe and then being re-installed after no more than minor cold rework of corners or edges (e.g., straightening).

This requirement shall also apply to door structures with the exception of transparent inserts.

(3) Doors shall be designed for an impact load of 50 pounds, uniformly distributed over an area of 4 square inches, at or near one of the free edges of the door in a horizontal plane. This requirement is additional to the normal design criteria for aerodynamic loading and/or wind loads applied while on the ground.

This is more applicable to hinged than to sliding doors and is intended to cover one of the more common types of "hangar-rash", viz., equipment being pushed into the aircraft, personnel stumbling against it, etc.

(4) For secondary structural items which are vulnerable to frequent impacts (e.g., avionic racks with compact arrangement of components), the most susceptible areas shall be defined and locally strengthened.

This requirement shall also apply to doors (hinged or sliding types) which impact against their travel limiting stops. A reasonable value of impact velocity shall be determined by the contractor, and the resultant loads shall be applied to the design of the door and detail components.

(5) Items of secondary structure which by design are required to sustain localized loadings shall be capable of sustaining such loadings within "θ^{o}" of misapplication from the intended design position.

An example of this would be fuselage steps which are generally designed for local vertical loading. However, such steps are often used by personnel to gain access to other, unforeseen, portions of structure or equipment by leaning out from the plane of such steps.

A practical value for "θ^{o}" would be open to discussion.

(6) To facilitate maintenance and replacement, consideration shall be given to attaching seals by means of sheet metal retainers with screws and nut-plates rather than bonding or riveting the seals to the basic structure. In the choice of seal materials, consideration shall be given to such areas as vulnerability and exposure to contaminants such as aviation fuel and hydraulic oil in addition to normal weathering. Also, when feasible, seals shall be fabricated from standard stock sections so that replacement does not involve procurement of special preformed parts.

(7) Where appropriate, Failure Mode and Effect Analyses (FMEA) shall be performed during design phases of secondary structures (such analyses are often performed on primary structural components) to enhance longevity and reliability of such structures and to highlight potential problem areas for special design attention.

(8) In the design of secondary structural components, consideration shall be given to the degree of abuse to which such components are likely to be subjected in field service. Design and construction shall reflect such consideration.

Also, when consideration is given to a sophisticated design technique (such as bonded honeycomb structures) this shall be balanced against possible expenditure of man-hours and degree-of-skill requirements necessary to effect field repairs.

PROPOSED NEW TEST CRITERIA

(1) Where such installations would not obscure primary structural areas of concern, secondary structural items shall be installed in their intended locations during airframe fatigue testing, if such testing is required by detail specification. This requirement shall also apply to equipment items of significant mass. These mass items may be simulated.

In some instances it may not be feasible to have the secondary structural items installed throughout the duration of test. However, effort should be expended to have them installed during some major portions of the testing, particularly during those vibratory regimes which are adjudged to be potentially most critical for the secondary structures in question.

This requirement is particularly applicable to items such as entry doors, cowlings and work platforms. The simulation of mass items would apply to items such as avionics racks.

(2) Secondary structural components such as work platforms, auxiliary walkways and steps shall be tested to simulate the effects of the appropriate number of 200-lb men upon them. The resultant loadings shall be applied in a manner and over such areas as are consistent with the intended use of the item.

For vibratory testing in accordance with new criterion 1, the 200-lb load(s) should be distributed over discrete areas representing, perhaps, standard footprint areas. For static testing, the load(s) may be distributed over larger areas.

(3) Major items of movable secondary structure, such as entry doors, shall be capable of sustaining "N" cycles of operation without failure in the basic structure or any associated mechanical components, as part of a structural validation and reliability demonstration. At least 50% of these cycles shall be intentionally "hard" operations.

For doors, the "hard" operations shall terminate with the components impacting against their travel limiting stops. The forces to be sustained during such impact loadings shall be proposed by the contractor in a test plan authorized by and acceptable to the procuring activity.

The value of "N" shall be selected by the contractor consistent with anticipated usage of the components throughout a service life of 5,000 flight hours.

PROPOSED NEW DESIGN/TEST CRITERIA: CONCLUSIONS

The intent of the foregoing proposed new criteria is to cover the foreseeable conditions to which secondary structural components will be subjected in their service life and for which definitions of criteria are feasible and practicable.

Some of these criteria are already being applied in design since they are no more than a formalization of applied common sense. Some others, of course, are the result of hindsight knowledge since there are few designers who, upon surveying past efforts, would not wish to make improvements on their

work if it were feasible.

A few of the criteria, particularly those directed toward reducing handling damage, arose from the writer's experience in liaison and maintenance operations and from familiarity with the normal working standards of the average run of maintenance personnel, both civilian and military.

If these proposed criteria prove to be feasible and acceptable, then their application in conjunction with failure mode and effect analyses should do much to improve the reliability and maintainability of helicopter secondary structures.

DISCUSSION

SELECTION OF SECONDARY STRUCTURAL COMPONENTS FOR TEST AND REDESIGN

In the choice of components for test and redesign, each component had to meet the following guidelines:

(a) It had to be troublesome in the past.

(b) It had a documented history.

(c) It could be redesigned in line with new criteria in an attempt to demonstrate improvements in maintainability and reliability.

(d) It is suitable for establishment of a test program.

Eliminated from consideration were components in which the prime failure causes were mishandling, abuse or corrosion, or components whose failure causes might be peculiar to the H-2 helicopter.

When these guidelines were applied to those components for which data are available in the Analysis of Operational and Overhaul Maintenance Data, only two components appeared as candidates. The components were sliding doors and box steps.

The sliding doors had discrepancies which appeared on more than 95% of all PAR's, with a high number of discrepancies per PAR.

Discrepancies on the box steps showed up on 88% of all PAR's, with an average of 3.3 discrepancies per PAR.

These, then, were the secondary structural components selected for the test and redesign requirements of this program.

PILOT RESCUE DOOR

DESCRIPTION OF TEST COMPONENT - PILOT RESCUE DOOR

The pilot rescue door is a large, roller-suspended, sliding type door located on the right-hand side of the forward fuselage of the Kaman H-2 helicopter (Figure 1). This door covers both the pilot's entrance to the cockpit and the rescue doorway immediately aft of the cockpit. The door consists of an inner and outer aluminum alloy skin riveted to an edge frame fabricated from preformed aluminum alloy channel members. The outer skin is essentially flat, having only the moderate curvature required for door contour. The inner skin is a rubber-press component formed into deep corrugated sections to provide the door with requisite stiffness. The door design and fabrication are consonant with normally accepted good practice for this type of structure. Two acrylic plastic windows, a large one for the pilot and a smaller one for the rescue doorway area, are embedded in rubber seals and mounted in the door structure. These windows are not intended for emergency egress since the entire door is designed to be jettisonable.

The roller suspension system consists of two rollers at the top edge of the door aligned in the vertical plane and two at the bottom of the door in the horizontal plane. The upper rollers are the main load-carrying components in the system. The lower rollers are only meant to be guide rollers and to restrain the door from outboard movement at the lower edge.

The door design specification required that in the closed position the door be double flush, i.e., that it fit snugly against the pilot's forward door post and fair smoothly against the aft vertical member of the rescue doorway. To accomplish this with the original airframe design (which has remained unaltered), the door is required to "tuck-in" as it approaches the forward limit of its travel, and this necessitates a rather complicated system of double tracks with somewhat differing curvatures to provide the required camming action. The upper tracks are of C-section and the lower tracks are of L-section. Door rigging is accomplished by moving the aft upper roller and shaft vertically upward or downward in a slot in a double-serrated fitting attached to the door structure. Details of the door and roller and track systems are shown in Figures 2 and 3.

TEST CONDITIONS - PILOT RESCUE DOOR

For the pilot rescue door, it was felt that the majority of the problems encountered in service arose from operation in a vibratory environment, as is common on all helicopters, and also from severe impact of the door against stops when opened and closed. Accordingly, it was decided to subject the door to vibratory testing and to open-close cycling.

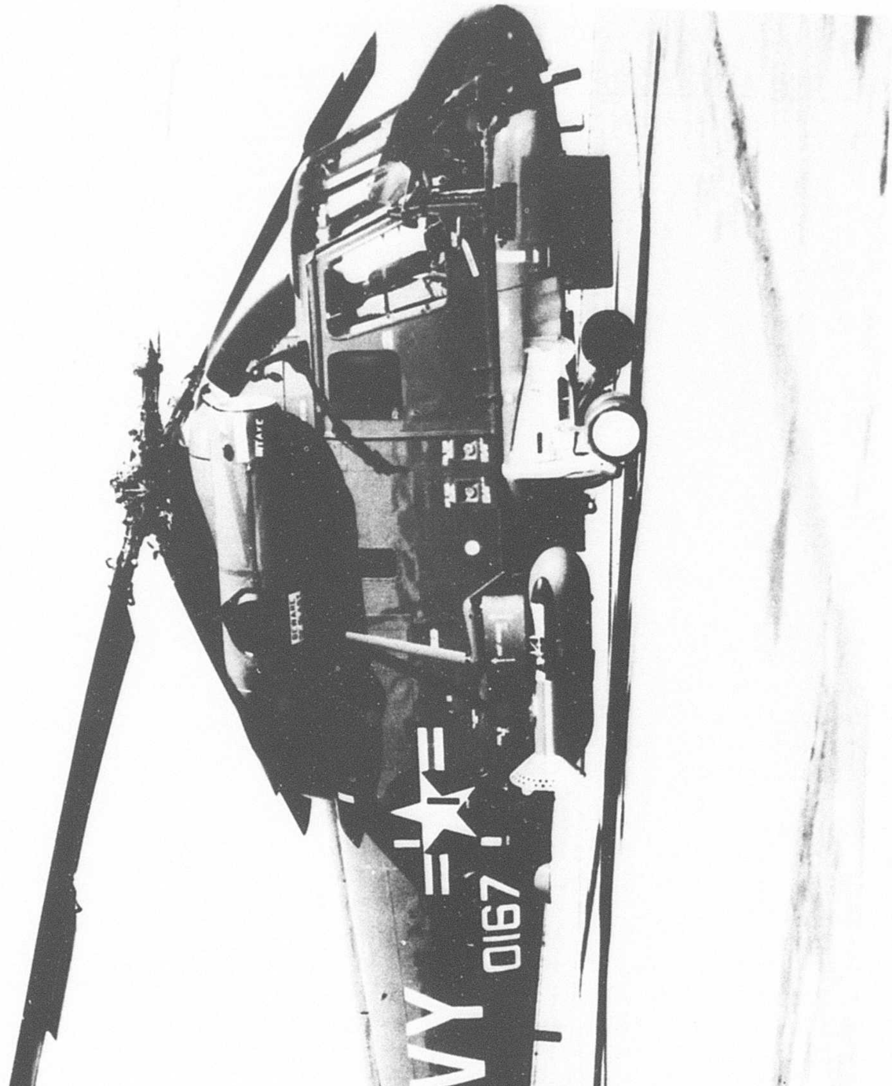


Figure 1. Kaman H-2 Helicopter.

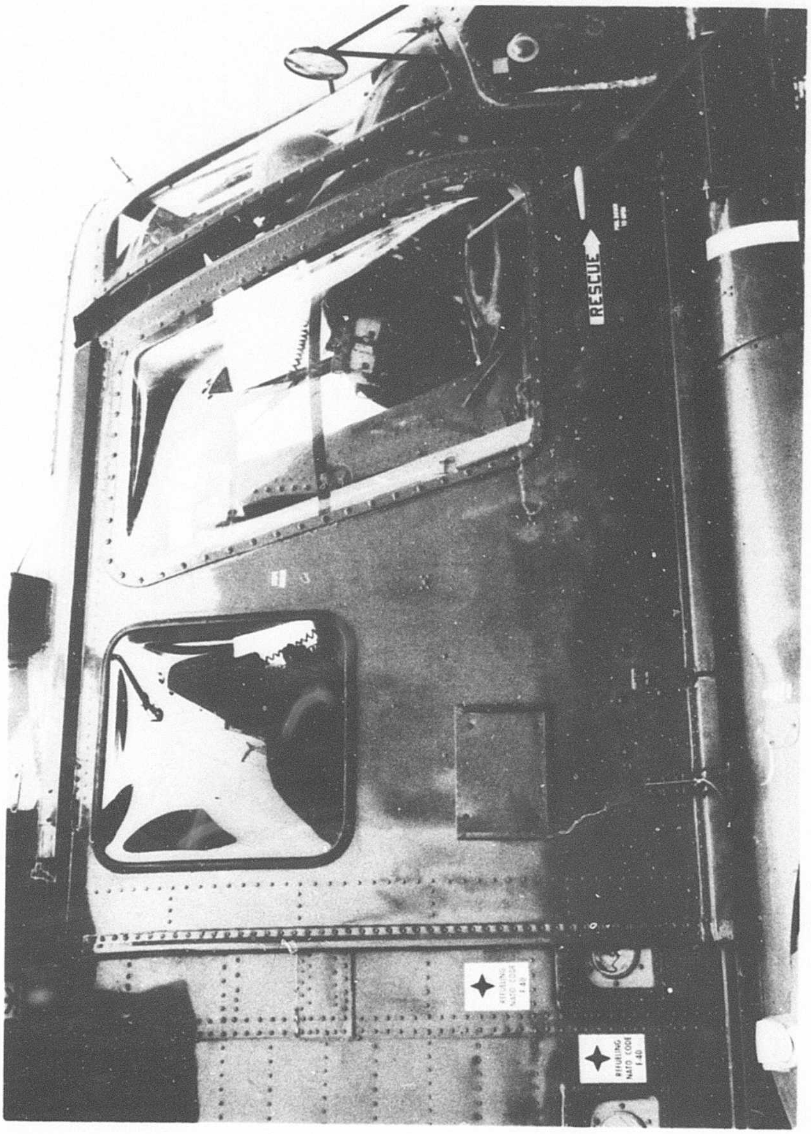


Figure 2. Pilot Rescue Door.

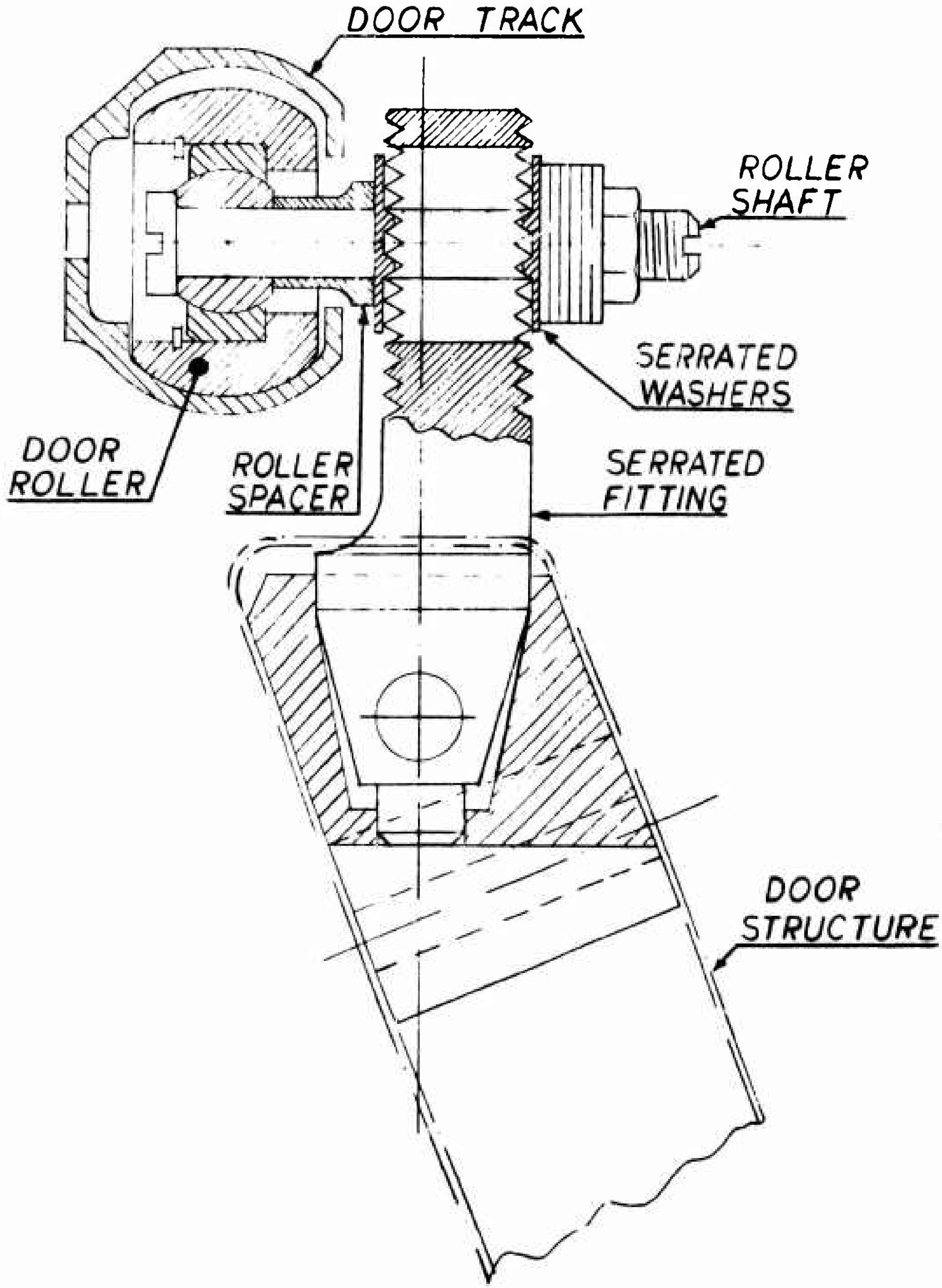


Figure 3. Enlarged Cross Section of Upper Aft Roller Assembly and Track (Pilot Rescue Door).

It was concluded that it would be reasonable to attempt to simulate the effects of 5,000 flight hours of in-service usage, and so this figure was used as a base datum.

Open-Close Cycling

It was assumed that five open-close cycles per flight hour would be a reasonable estimate of usage and that 20% of these would be hard openings.

For test purposes:

Number of Hard Open-Close Cycles =

5000 (flight hours) x 5 (open-close/hr) x

20% (hard open-close) = 5,000

Vibratory Testing

On the H-2 helicopter, the flight regimes in which significant vibrations are encountered are in the speed ranges 20-40 knots and above 125 knots. Flight surveys had shown a vectorial combination of vertical and lateral accelerations of $\pm$ .37g in these critical speed ranges. Conservatively, 20% of flight time is spent in these ranges.

In order to compress the time scale on testing, it was decided to run the test at double the expected flight vibration level, i.e., at $\pm$ .75g. The applied cyclic rate would approximate a 4-per-revolution frequency on the main rotor.

Number of hours of vibratory testing =

5000 (flight hours) x 20% (time with significant vibration) x 1/4 (factor for load acceleration) = 250 hours

These figures of 250 hours of vibratory testing and 5,000 open-close cycles led to the decision to conduct the test in 10 blocks of 25 hours of vibratory testing followed by 500 open-close cycles.

It was estimated that the door would probably be opened to the first latch detent position, to improve cockpit ventilation, for approximately 70% of the flight time. Consequently, in each 25-hour test block, 7.5 hours of vibratory testing was to be performed with the door in the fully closed and latched position and 17.5 hours with the door

open to the first detent position.

Another item which was felt to be of significance in reported door problems was mis-rigging of the door. The rigging procedures are such that the door can be adjusted either tightly or loosely between its upper and lower tracks, and service experience tends to indicate that the door will probably be misrigged for about 30% of its service life.

Since it was intended to run the vibratory testing in 10 blocks of 25 hours each, it was decided to conservatively assume that mis-rigging occurs during 40% of the test, thus giving 50 hours mis-rigged tightly and 50 hours mis-rigged loosely.

The door test procedure, then, consisted of an intermix of 25 hours of vibratory testing followed by 500 deliberately hard openings and subsequent closings. The sequence is shown in Table I.

TABLE I. TEST CONDITIONS FOR PILOT RESCUE DOOR

TEST BLOCK	RIGGING CONDITION	VIBRATORY TESTING (HR)	OPEN/CLOSE CYCLES
1	Nominal	25	500
2	Nominal	25	500
3	Loose	25	500
4	Loose	25	500
5	Nominal	25	500
6	Nominal	25	500
7	Tight	25	500
8	Tight	25	500
9	Nominal	25	500
10	Nominal	25	500

The loading sequences shown in Table I were applied to both the current design and modified design doors.

TEST SETUP - PILOT RESCUE DOOR

The current design door was installed on Kaman's H-2 Static Test Helicopter BuNo. 147205.

An electromechanical shaker of a design similar to that shown in Figures 4 and 5 was affixed to the door at the center of mass in such a manner as to apply the resultant of the vertical and lateral vibratory acceleration components. The shaker consists of two counterrotating eccentric weights which produce an alternating force in one plane only and are driven by an electric motor via a flexible shaft. This apparatus was adjusted to produce a vectorial vibratory acceleration of $\pm$ 3/4g at a cyclic rate of 1,080 per minute, which is equivalent to a 4-per-revolution condition on the aircraft with the main rotor rotating at 270 rpm. Accelerometers were mounted on the door to monitor the vertical and lateral accelerations.

Because there was no economically feasible method of automating the open/close cycling, this portion of the testing was performed manually. In order to maintain a relatively consistent minimum force on the door during this cycling, a deceleration force indicator similar to that shown in Figure 6 was attached to the aft edge of the door. This indicator was set by means of the force adjusting bolt to simulate what was generally agreed, by experienced service personnel, to be a hard door opening. In the indicator, as the door is moved aft and contacts the stop, the inertia force on the steel ball causes it to compress the spring and make contact with the end of the adjusting bolt which completes an electrical circuit, energizing an indicator lamp and digital counter. This ensures that although some openings may be harder than the agreed-upon level, none will be lower.

TEST RESULTS - CURRENT DESIGN - PILOT RESCUE DOOR

Test Block No. 1

25 hours vibratory testing.
500 open-close cycles.

The door was set in the normal-rigged position and testing commenced.

The 25 hours of vibratory testing were accrued with no untoward events noted.

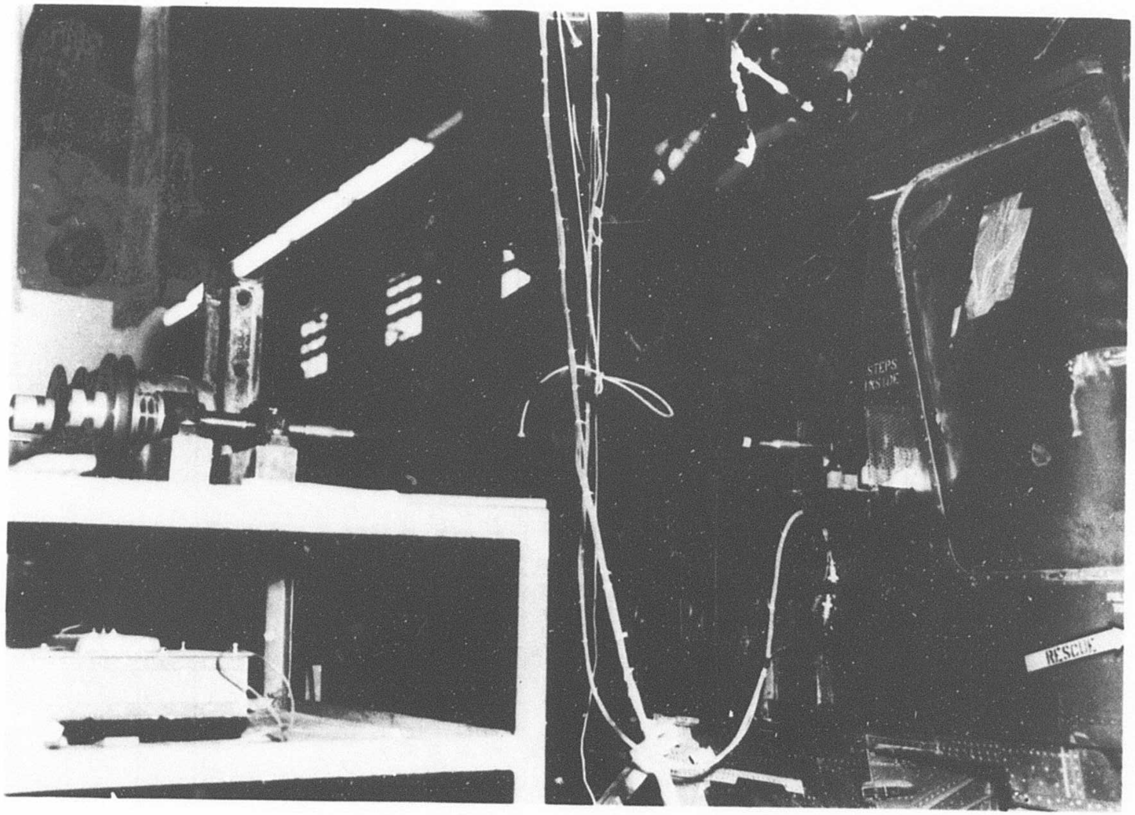


Figure 4. Test Setup for Pilot Rescue Door.

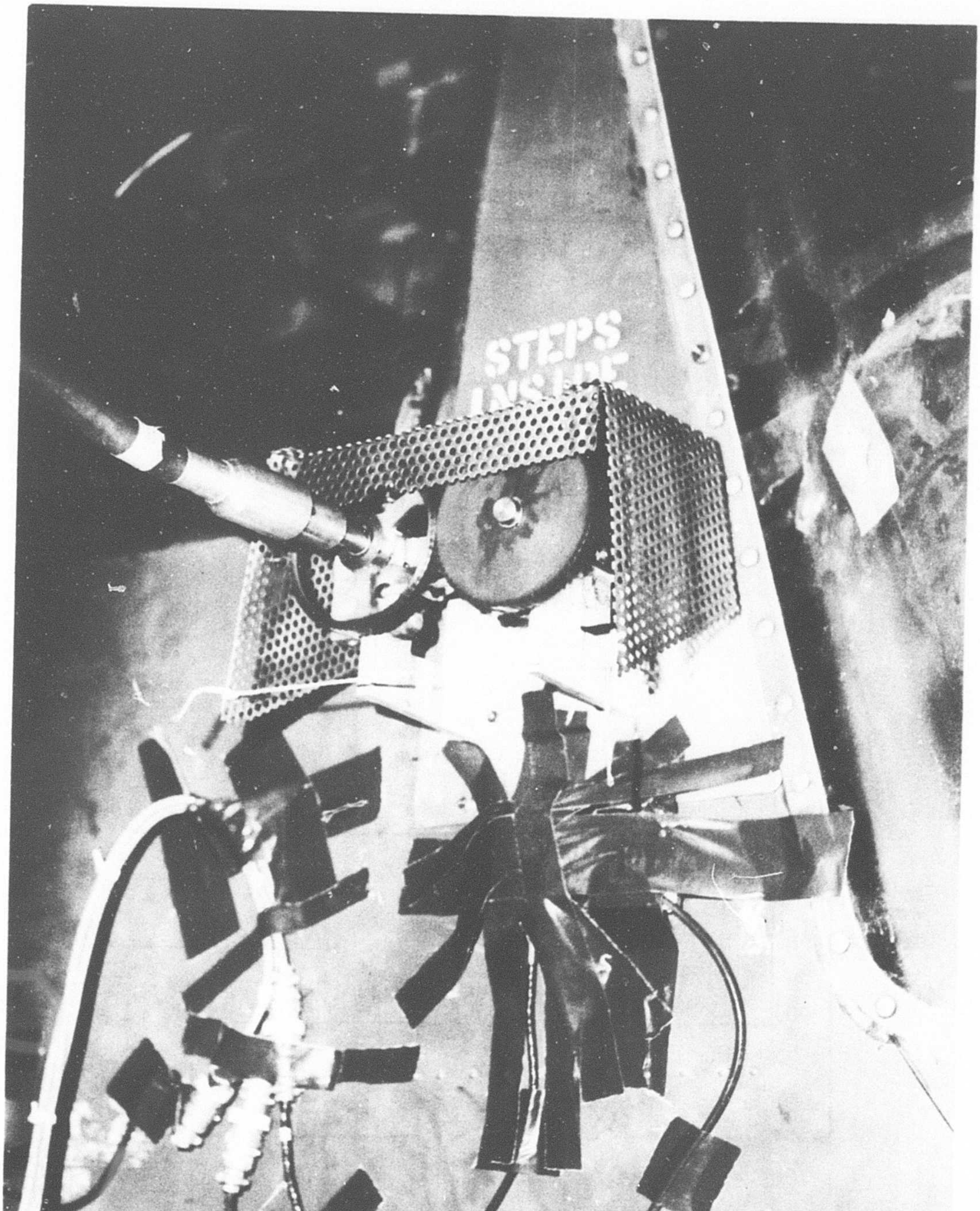


Figure 5. Close-Up View of Electromechanical Shaker on Pilot Rescue Door.

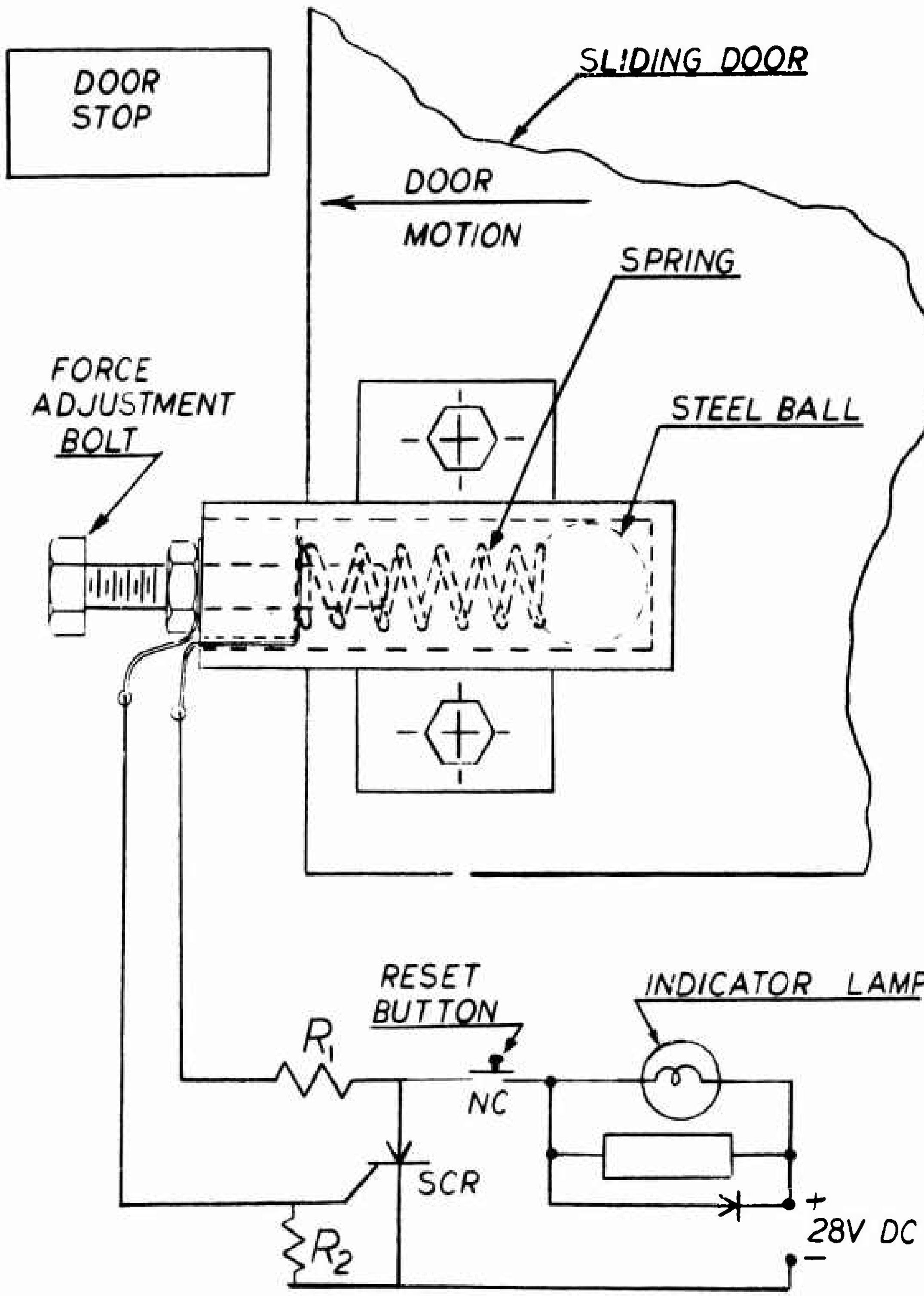


Figure 6. Minimum Deceleration Force Indicator on Pilot Rescue Door.

During the open-close cycling, the aft upper roller shaft broke on the 88th cycle. This permitted the door to move aft past the stop and to become disengaged from the tracks. The aft lower roller support bracket, which is a casting, was fractured in the resulting fall. New current design parts were installed, replacing those which had been broken, and 500 open-close cycles were applied to the door without incident.

Subsequent investigation revealed that the shaft which broke was an obsolete part which had a rather severe undercut at the thread runout area. The undercut is the only difference between this obsolete part and current design shafts. The failure was through the undercut (Figure 7). This failure was discounted as being invalid for the current design.

Test Block No. 2

25 hours vibratory testing.
500 open-close cycles.

Door in normal rigged position. At 30.75 hours accumulated vibratory it was observed that the door was rattling somewhat more than normal. The shaker was shut down and it was discovered that the aft top roller was loose. The roller was tightened via the roller shaft as would be expected to be done in the field, and the test resumed. (See Figure 10.)

Test Block No. 3

25 hours vibratory testing.
500 open-close cycles.

Door in "mis-rigged tight" condition. This test block was uneventful.

Test Block No. 4

25 hours vibratory testing.
500 open-close cycles.

Door in normal rigged position. Upon completion of this test block, it was discovered that the forward top roller was loose. It was also discovered that the roller spacer was evidencing signs of distortion (Figure 11). The distortion was not so severe that the bushing would have been replaced in field service, and so the roller shaft was tightened and the test resumed.

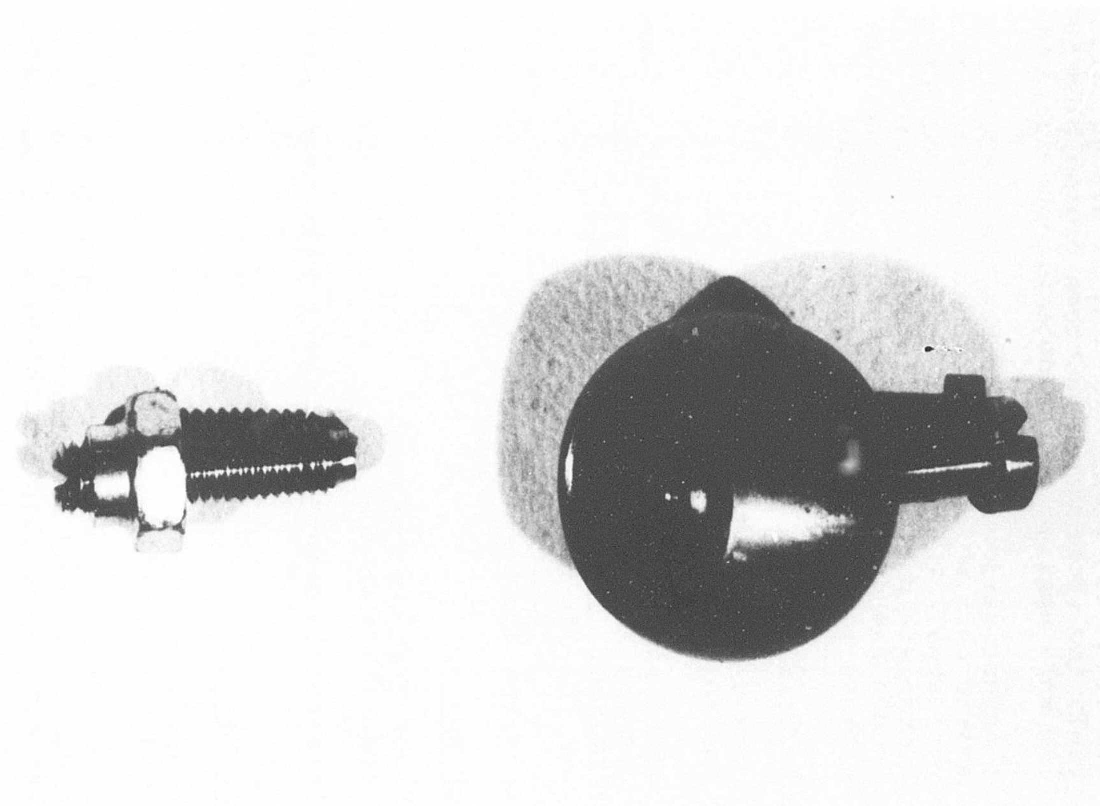


Figure 7. Failure of Undercut Roller Shaft on Pilot Rescue Door.

Test Block No. 5

25 hours vibratory testing.
500 open-close cycles.

Door in normal rigged condition. At an accumulated vibratory test time of 114.9 hours, the roller spacer at the top front location had deformed so badly (Figure 11) that the door had dropped slightly, thus allowing the spacer to contact the lip of the track. The standard field fix in this situation is to install an NAS-75-3-10 bushing in place of the damaged spacer. This was done and the testing resumed.

Test Block No. 6

25 hours vibratory testing.
500 open-close cycles.

Door in normal rigged position. At the completion of this test block it was found that the aft latch detent was loose. This detent is a flat steel plate with a notch in its outboard edge. The plate is bolted to the top surface of the lower track. These bolts were retorqued.

During the open-close cycling, it was observed that the door motion was exhibiting some slight drag. It was discovered that the upper forward roller had a moderate flat spot and that the upper aft roller had a somewhat more severe flat spot. The upper track was inspected and found to be in excellent condition with no discernible evidence of wear. Testing was resumed.

Test Block No. 7

25 hours vibratory testing.
500 open-close cycles.

Door in normal rigged position. The 25 hours of vibratory testing were completed. The door had now been subjected to a total of 175 hours of vibration and 3,000 open-close cycles.

At the beginning of the open-close cycling for this test block, considerable resistance was encountered to door motion. The upper rollers were disassembled, and it was found that the forward roller had such a large flat spot that it would no longer roll (Figure 9). The aft roller had several large spots (Figure 8), its roller shaft was severely bent (Figure 8), and its spacer showed considerable deformation (Figure 11).

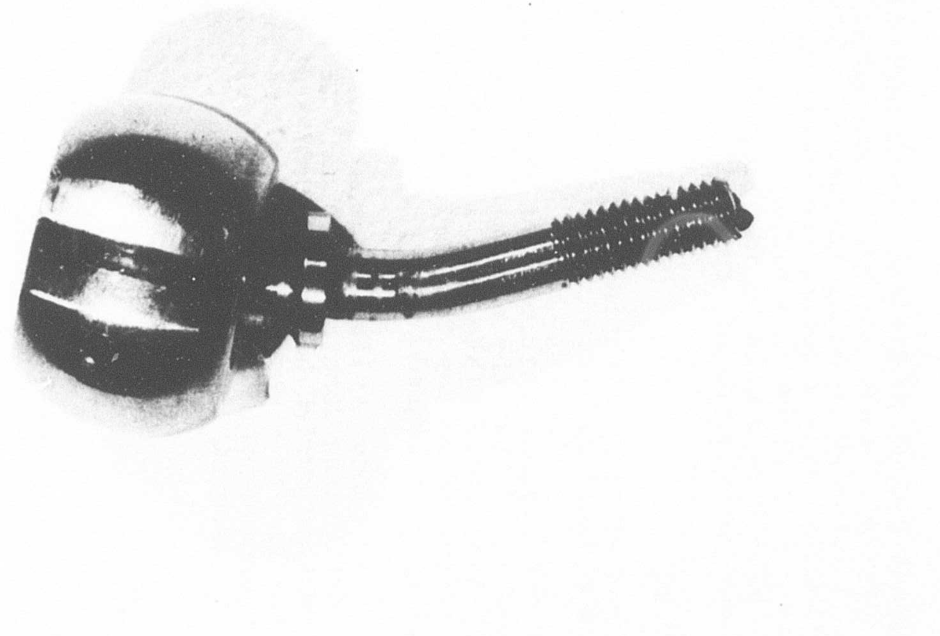


Figure 8. Bent Roller Shaft and Flat Areas on Upper Aft Roller on Pilot Rescue Door.

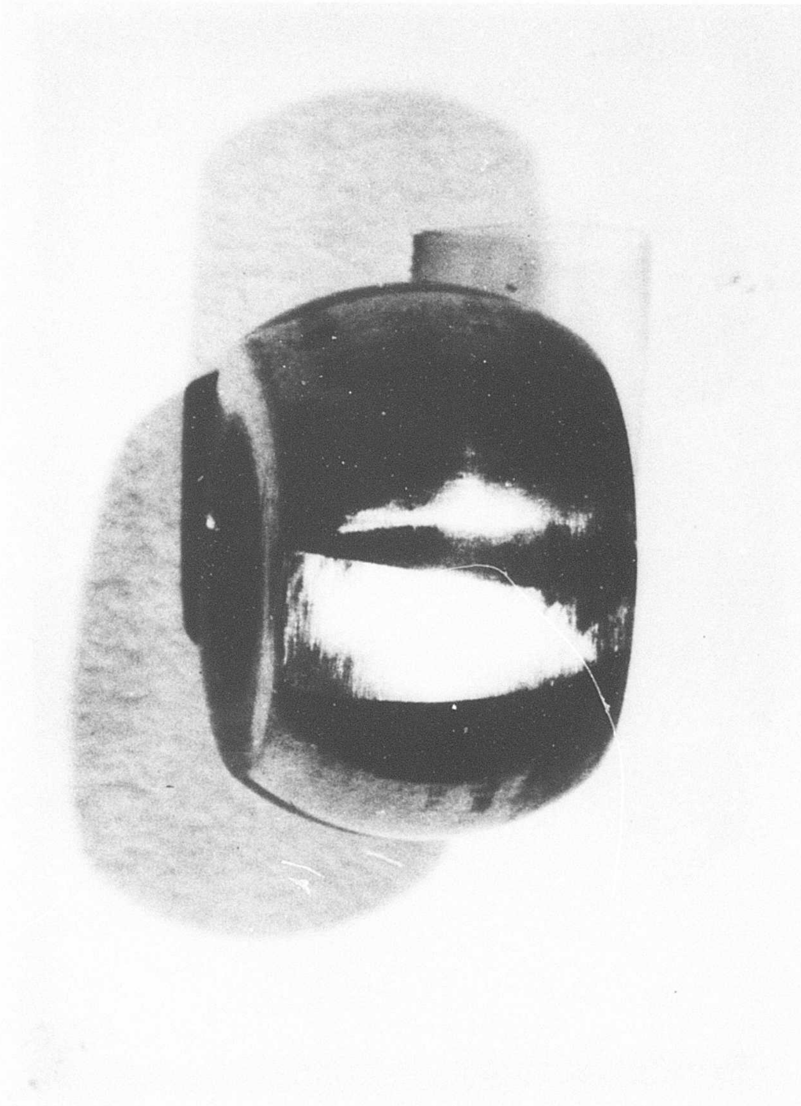


Figure 9. Large Flat Area on Upper Forward Roller.

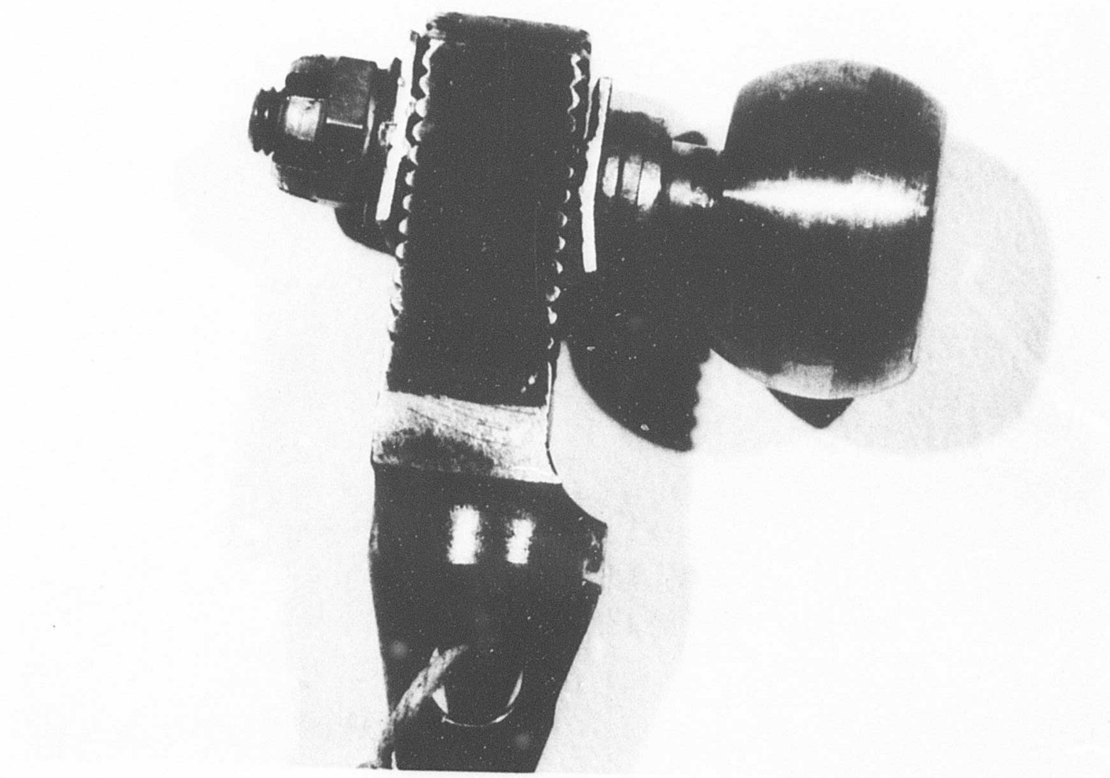


Figure 10. Upper Aft Roller Assembly Showing Deformation of Serrated Washer and Wear Pattern on Roller.

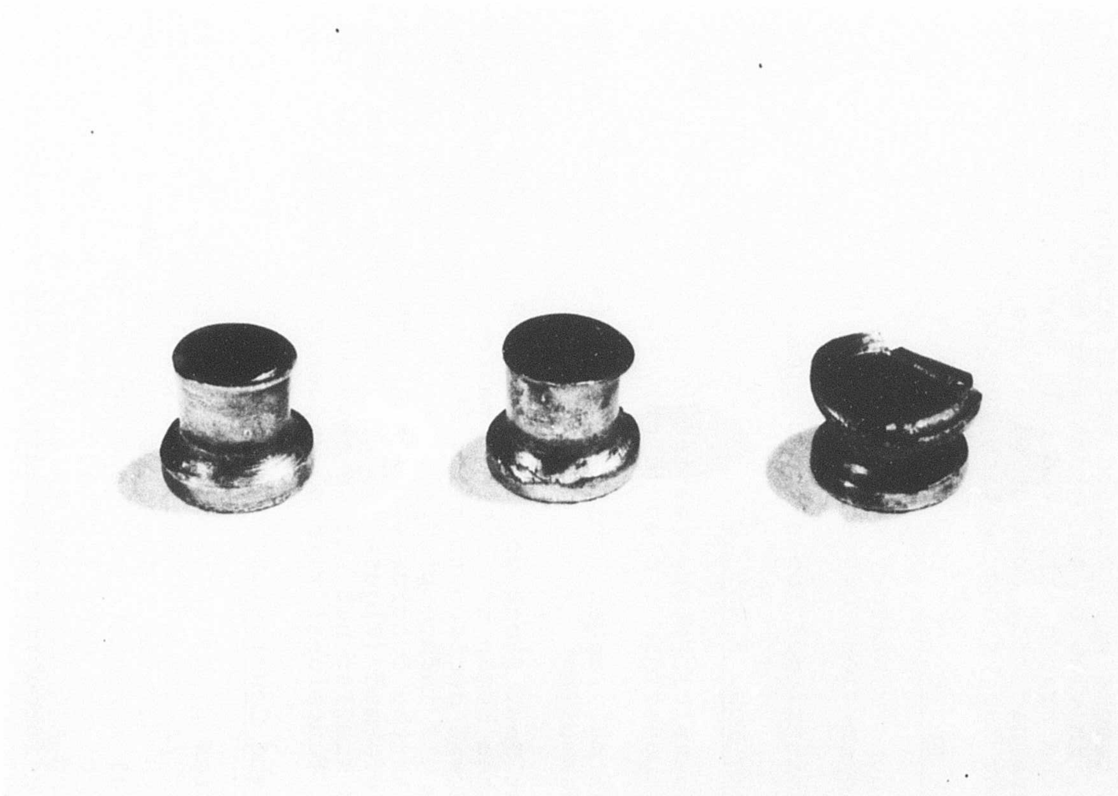


Figure 11. Progression of Failure in Roller Spacer.

In consonance with normal field procedure, these components were replaced with the exception of the spacer, for which an NAS-75-3-10 bushing was substituted for the reason noted in Test Block No. 5 above.

The upper tracks were cleaned and thoroughly inspected. Surprisingly, in view of the gross wear on the steel rollers, the aluminum tracks exhibited only very slight wear marks where the rollers had made contact with them. The door was reassembled on the tracks and testing resumed.

<u>Test Block No. 8</u>

25 hours vibratory testing.
500 open-close cycles.

Door in "mis-rigged loose" condition.

<u>Test Blocks Nos. 9 and 10</u>

25 hours vibratory testing.
500 open-close cycles (each).

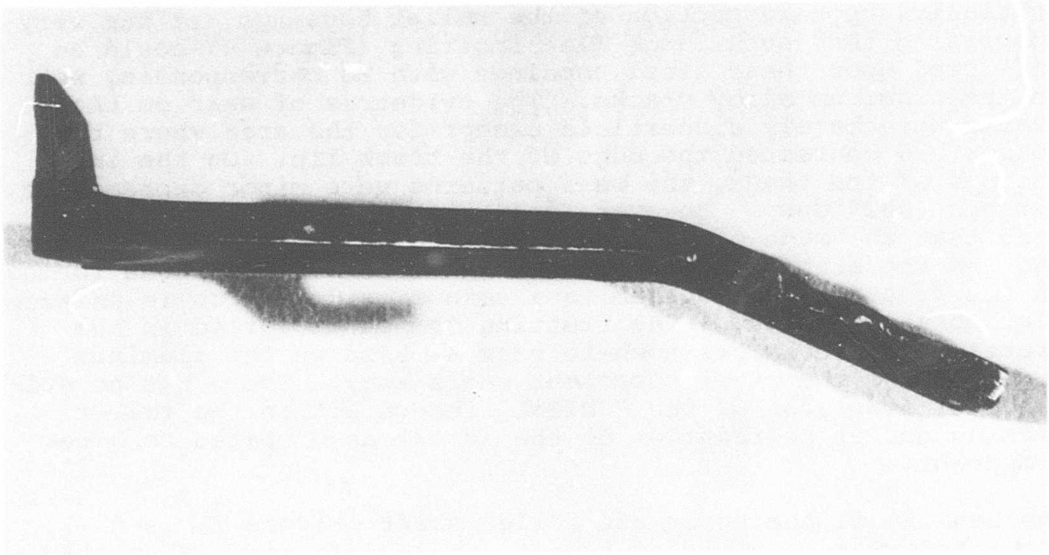
Door in normal rigged condition. No further discrepancies in roller assemblies.

From about Test Block No. 3 and onward, the forward and aft door latches began exhibiting progressive evidence of deformation. It was decided to allow this to continue to determine if this would induce problems in other areas of the linkage system. At the conclusion of the test, the aft latch was grossly deformed (Figure 12) and the damage to the forward latch was similar but not so severe. However, the lock linkage was still functional with no evidence of damage.

<u>Findings and Conclusions</u>

The failures experienced during the current design test were all on peripheral hardware, i.e., rollers, roller shafts, spacers and latches. There were no failures in the basic sheet-metal structure of the door, in the tracks, or in the remainder of the door locking mechanism excluding the latches. The locking mechanism was still operating freely with no evidence of deformations or binding in its functioning parts.

It is seldom that small hardware components which fail in field service are returned to the design office for inspection and evaluation, and so most of these failures were actually being seen for the first time, although they had been reported in service bulletins in the past.



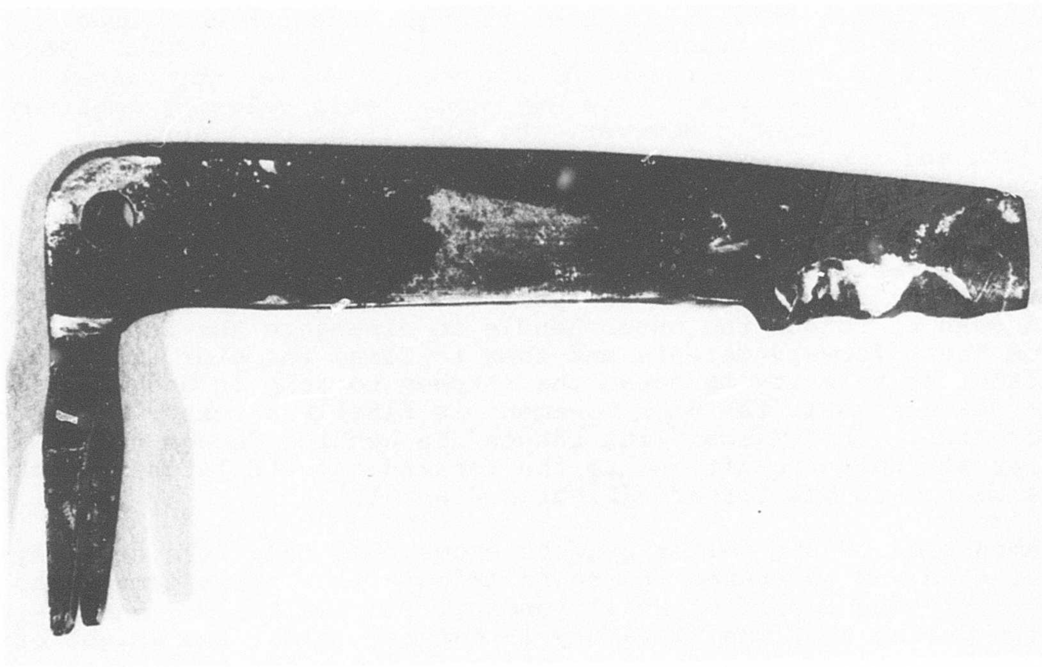


Figure 12. Two Views Showing Damage to Aft Latch on Pilot Rescue Door.

Initially, upon inspection of the roller housings, it was very surprising that such large flat-spotting (Figure 9) could be inflicted upon these steel housings with no corresponding wear in the aluminum alloy tracks. The evidences of wear on the tracks were barely discernible except for the area where the spacer had contacted the edge of the track lip. On the inner contour of the track, the wear patterns were minor depressions, perhaps .002" deep. However, upon reflection, it became evident that the mode of wear was fretting between the steel housing and the aluminum track. One of the common compounds formed in the fretting of aluminum is aluminum oxide, which is an excellent abrasive medium. The fretting compounds formed in the fretting of steels are nowhere near as hard as the aluminum oxide,and so the steel component wears away. There was no evidence of looseness of the "UNIBAL" insert within the roller housing nor of degradation of the insert as compared to a new component.

The bending of the upper aft roller shaft (Figure 8) is a straightforward example of impact damage. In the design stages of the door,no major consideration was given to the upper aft roller contacting the stop in the upper track. For all practical purposes, this stop was only to prevent the door from rolling out of its track in the event that the aft "FULLY OPEN" detent should for any reason be bypassed. It was not visualized that the door would have any appreciable velocity imparted to it at this point. However, the door is of considerable length and the external handle is located near its forward edge. This means that to move the door from the fully closed and locked positions to the fully open and latched positions requires a longer travel than is comfortable for the average or shorter-statured person to manage from a fixed stance. As a result, the tendency on the part of the service personnel has been to rotate the outer handle to disengage the latches from their forward detents and then to fling the door aft with sufficient velocity to cause the latches to jump in and out of the detents until the door movement is finally arrested by the door stop. This mishandling causes the bending damage to the upper aft roller shaft and to the forward and aft latches,which are caused to bow forward (Figures 8 and 12).

Examination of the roller spacers shows that they were severely distorted and shortened in length (Figure 11). This damage was obviously the result of axial loading, and the loading encountered during test was vibratory in nature. Also, the weight of the door suspended on the two roller shafts tends to bias the load distribution onto small areas of contact at the lower edge of the spacers. The cylindrical portion of the spacer is approximately .255" outside diameter with an approximate wall

thickness of .033", and thus it does not require much hammering action to induce deformations in this thin-walled section. Once the deformations have begun, the spacer begins to decrease in length. This introduces a lack of fit between the roller and the attachment fitting in the door and allows a buildup of amplitude in the relative motion between the door and track, which hastens the failure of the spacer. The increased motion is of course also felt by the rollers and contributes to the increase in the rate of wear on the roller housings.

CURRENT DESIGN TEST RESULTS VS. OPERATIONAL EXPERIENCES

The operational experiences on the aircraft sliding doors are summarized as follows:

1. Sliding Door Seals. Seals deteriorate, tear, and loosen through handling damage and exposure to the elements.

2. Rain Shield Fairings. Rain shields become torn, cracked and broken as a result of exposure to elements, aircraft wind-stream and personnel handling.

3. Door Handle Linkage. Handle and linkage become corroded and worn. Linkage binds, causing parts to be overstressed.

4. Roller Assemblies. Door rollers become corroded, worn, cracked and broken, causing doors to loosen and creating excessive track wear.

5. Door Tracks. Upper and lower sliding door tracks become worn, cracked and broken. (Failure of tracks is associated with door roller problems.)

6. Door Jettison Mechanism. Jettison mechanism becomes frozen and inoperative. This condition is attributed to corrosion.

Checking this summary against the current design test results, it can be seen that the areas in which there is good correlation are the roller assemblies. This correlation is very good concerning roller wear. There was some minor wear noted on the door tracks during the test but not of sufficient severity to indicate the possibility of impending failure.

The lack of correlation in the other areas is due to the fact that no attempt was made to simulate the effects of corrosion or mishandling of the components which appear to be the major failure causes for items other than rollers and tracks.

During the test program, no bending of the door handle linkage was encountered; however, considerable deformation of the door latches was induced. This particular discrepancy is not noted in the operational experience, which refers only to binding of the mechanism. A survey was conducted on aircraft which had been returned from service for model up-dating, and on at least 60% of them the latches had developed slight bowing as checked by a straightedge laid along the latches. With new latches engaged in the first detent position, the pilot door is opened approximately two inches for ventilation. The only effect of bowed latches is to cause this two-inch gap to gradually widen. With the gross deformation of the latches encountered in the test program, the door opening had increased to approximately 2.30 inches, but the latches would still engage in their detents. This is probably why latch bending is not noted as a problem although it is a distinct long-term failure mode.

It can be seen that for most areas in which testing could be expected to produce meaningful results, viz., wear due to vibration and usage of the door lock mechanism, the test results did correlate quite well with operational experience. The one significant area of noncorrelation was in the door tracks, which did not sustain any failures during test. It should be pointed out that although the tracks were frequently inspected during the test program, no special preventive measures were exercised, other than an occasional wipe-down of the tracks, which is no more than would be done in the field.

Thus, if a full-scale test program had been conducted on the doors early in the aircraft test development, most of the significant field failure modes would have been highlighted for special attention. Such a comprehensive program would have specified fatigue testing for the doors and demonstration of structural integrity under repeated open-close cycling of the door as suggested in the new criteria section of this report.

DETERMINATION OF WHETHER PRIOR ANALYSIS COULD HAVE PREDICTED EXPERIENCED FAILURES ON PILOT RESCUE DOOR

For the pilot rescue door, the critical design consideration was the application of aerodynamic loads resulting from a high-speed yawed flight condition. This designed the basic door structure. Consideration of a 20g forward crash condition with the door latched open produced the design loads for the latches

and local attachment points. Since the latches are located at the bottom edge of the door and the door is suspended from two rollers at the top edge, this condition also induced appreciable differential vertical loads on the rollers, which in turn led to bending considerations on the roller shafts. In the original design and analysis, no consideration was given to the effects of hard openings or closings of the door nor to detailed fatigue analyses of door components.

If consideration had been given to hard opening of the door, then it would have become evident that when the aft upper roller contacts the door stop, it induces cantilever bending into its roller shaft. However, it would have been impractical to attempt analytical prediction of the forces which would be involved in a typical "hard" opening.

Concerning the roller spacer failures, it is extremely doubtful that they could have been predicted even under the most detailed scrutiny. In normal use, the spacer is clamped between the door attachment fitting and the roller by means of the roller shaft. This in effect makes a monolithic component, and attempting to sort out individual component failures is well-nigh impossible.

With the design clearance envelope existing between the tracks and rollers, it was recognized that wear on either or both components was a distinct possibility due to relative motion between them. However, the prediction of wear on two components and whether one component will wear more than the other is rather nebulous and is virtually a separate engineering discipline on its own. For the pilot rescue door on the H-2 helicopter, no attempt was made to apportion the probability of wear between the rollers and tracks since it was felt any such problems would only result from long-term service and would pose no particular difficulties in the field.

In summary, it is felt that of those failures encountered in the field and corroborated by the test program, only the roller shaft failure could have been predicted with any degree of certainty in the design stages. However, it should be noted that consideration of a hard opening of a door has never been a normal design criterion. This problem does not exist in a hard closing since the seal along the forward edge of the door acts as a very efficient cushion in contact with the cockpit door frame.

It should be pointed out that if test requirements such as those proposed in new criteria No. 1 and No. 7 had been in force at the time of this door design, then these failures

would have been highlighted and could have been corrected in the early production run.

See also the results of the Failure Mode and Effects Analysis in its own section in this report.

COMPONENT REDESIGN CONSIDERATIONS

The recorded field experience on the pilot rescue door is summarized below:

1. Seals. Seals deteriorate, tear and loosen through handling damage and exposure to the elements.
2. Rain Shields. Rain shields become torn, cracked and broken as a result of exposure to the weather and aircraft wind-stream and through handling damage.
3. Door Handle/Linkage. Handle and linkage become corroded and worn. Linkage bends causing parts to be overstressed.
4. Roller Assemblies. Door rollers become corroded, worn, cracked and broken, causing doors to loosen and create excessive track wear.
5. Door Tracks. Upper and lower tracks become worn, gouged, cracked and broken. Failure of the tracks is associated with roller problems.

It was intended to attempt to eliminate or reduce these problems by the application of new design or test criteria. In line with this attempt, the following comments were pertinent to the foregoing summary of field experiences.

Items Nos. 1 and 2 are time/environment dependent conditions, with abuse or mishandling also being significant contributing factors. No definable criteria other than general admonitions concerning care in selection of materials could help obviate these problem areas, and therefore no detailed consideration was given to them.

Item No. 3 was caused by corrosion compounded by lack of inspection and lubrication requirements. It should be noted that References 16 and 17 have requirements which became effective sometime after this design entered production, that such linkages shall be of corrosion-resistant materials or adequately protected against corrosion and shall have positive means for

lubrication. Therefore, this item was covered for future designs and no definition of new criteria was required.

This left items Nos. 4 and 5 to which new criteria might gainfully be applied.

Ignoring corrosion on the roller assemblies, then, the major problems in the field were reported as worn, cracked and broken rollers. The reported wear on the rollers was readily appreciated, since reference to Figure 3 shows that clearance exists between the outside surface of the roller and the inside contour of the track, and in a vibratory regime as is found on all helicopters, such clearance is translated into relative motion between the parts with consequent fretting wear. The reports of cracked and broken rollers could not readily be attributed to vibration, and so possible causes were sought by further investigation.

Discussions with maintenance and service engineering personnel elicited the information that the write-ups of cracked and broken did not refer to the rollers themselves, but, rather, to the roller spacer and roller shaft shown in Figure 3. It now became easier to understand the cause of these failures.

The aft stop for this door consists of a contoured phenolic block nested within and pinned to the upper door track. Bonded to the forward face of this phenolic block is a small rubber pad against which the aft upper door roller is intended to contact in the event that the aft latch detent position should be bypassed. This bumper pad is frequently lost, and the roller is then subjected to impacts against a relatively unyielding surface during hard door openings. Maintenance personnel also pointed out that the door is of such a size that moving it from the fully closed to fully open positions cannot comfortably be performed with one easy arm motion. The general tendency therefore is to rotate the handle initially to release the latches and then to slide the door aft with considerable velocity. This results in frequent applications of cantilever type loading, of varying degrees of severity, on the roller shaft, ultimately leading to failure of this component.

The failures of the roller spacers were not so readily understandable, but it was felt that vibratory pounding was largely responsible for them. This was verified when the failures of the roller spacers became evident during the current design testing program (Figure 11). This vibratory pounding is of course nothing more than high-frequency impact loading.

It thus became evident that improvements could probably be shown in the roller shafts and roller spacers by minimizing the effects of impact loading on these components. This would be in accord with proposed new design criterion No. 4.

The current design roller spacer is a thin-walled cylinder having a flange at one end (Figure 3). The wall thickness of the cylindrical section is 0.03". Increasing this wall thickness would decrease the clearance existing between the outside diameter of the spacer and the lower lip of the track, and this was not felt to be desirable. Instead, the roller spacer was redesigned by adding a flange similar to the existing one at the end of the cylindrical portion of the spacer body. This introduced a large flat area in contact with the ball of the roller, and it was felt that this would make the spacer much more resistant to impact failures. This redesigned spacer is shown in Figure 19.

In order to improve the condition on the roller shaft, it was decided to eliminate the cause of the cantilever loadings to which it is subjected in service. This was done by eliminating the door stop from the track and relocating it. Since it was now understood that the door could be expected to be frequently slammed against the stop, its design and location were given careful consideration. It was finally decided to locate the stop at the approximate waterline location of the C.G. of the door. This location minimizes any cocking action experienced by the door upon impact against the stop. The stop structure, which is illustrated in Figure 13, consists of two tapered channel section members located externally on the fuselage in a waterline plane. Located between these channels and attached to their webs is a tapered box-section member with a generous sized rubber bumper attached to it. One of the channels picks up an existing row of intercostal rivets, and an angle-section intercostal was added to provide backup structure for the other channel. A steel striker plate was attached to the stop contact area on the aft edge of the door (Figure 15) to protect the door sheet-metal structure.

Much effort was expended in investigating possible approaches toward reducing wear on the roller housings. The problem in this area is that in order for a track-roller combination to function, there must be clearance between the rollers and the track. This required clearance leaves open the possibility of relative motion between the components, which leads to wear problems. It is possible to minimize the clearance envelope; however, beyond a certain value it requires an inordinate expenditure of funds to gain a minimal return in a tighter tolerance envelope. An extremely tight clearance envelope would

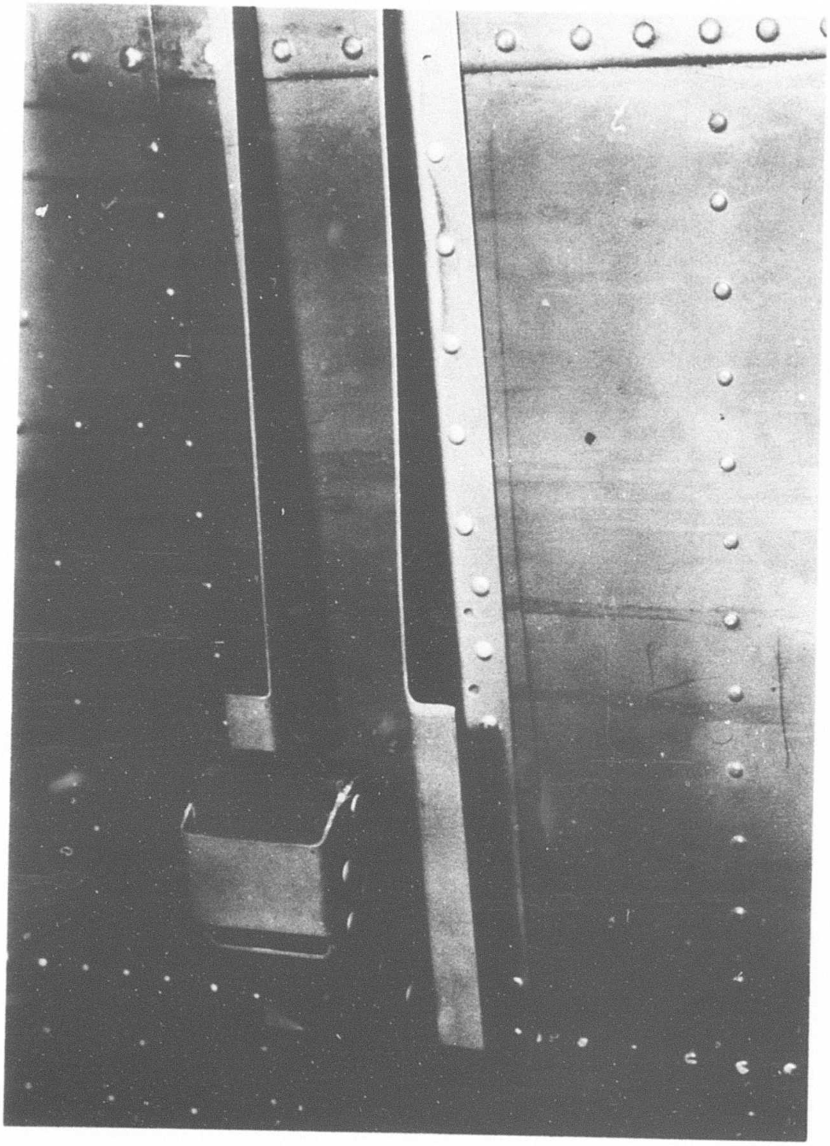


Figure 13. Installation of New External Door Stop (Post-Test).

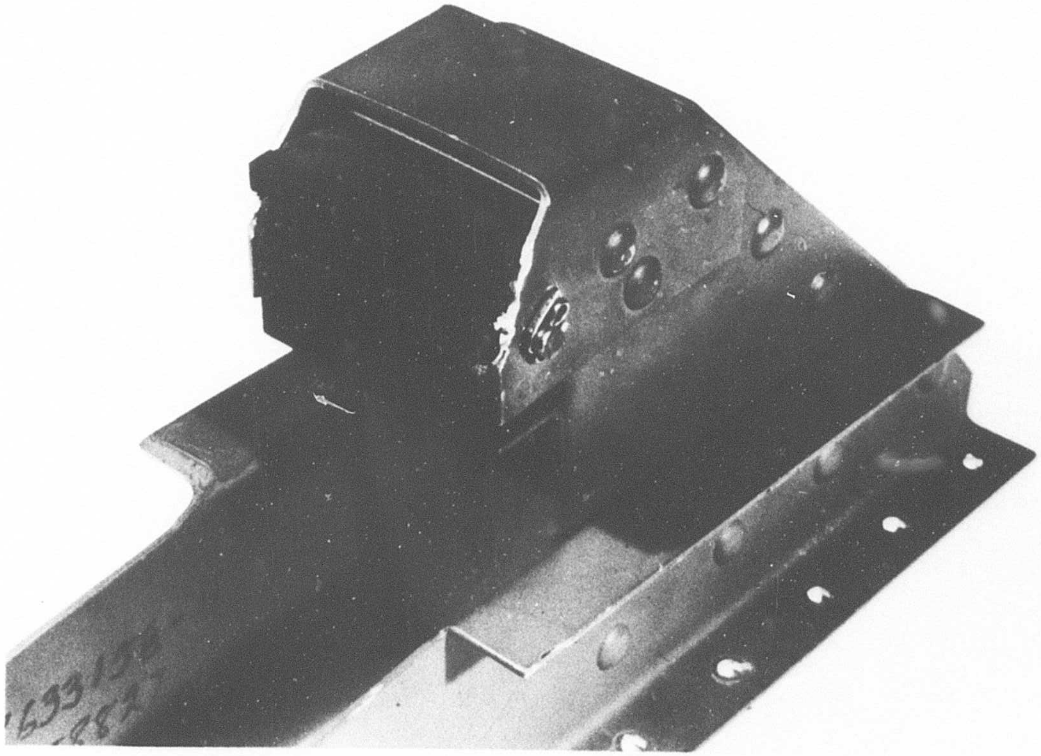


Figure 14. Detail Showing Damage Sustained by New Door Stop.

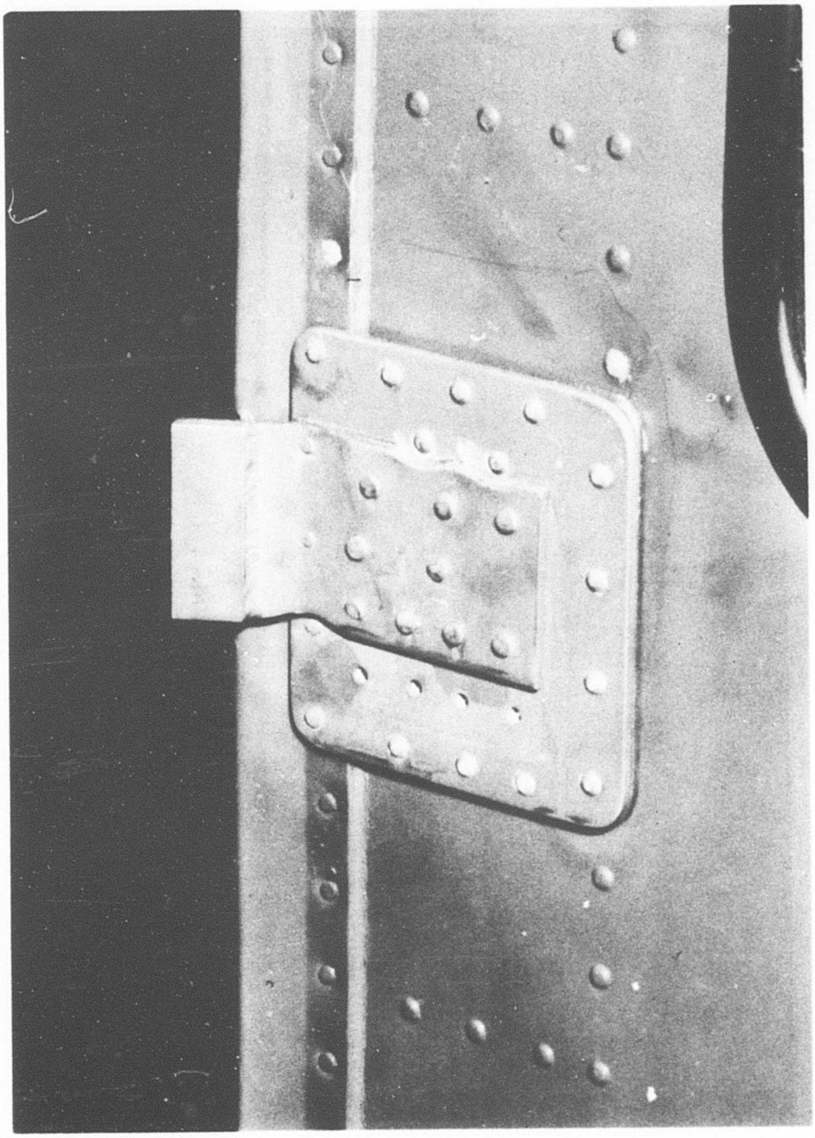


Figure 15. New Design Striker Plate on Aft Edge of Door.

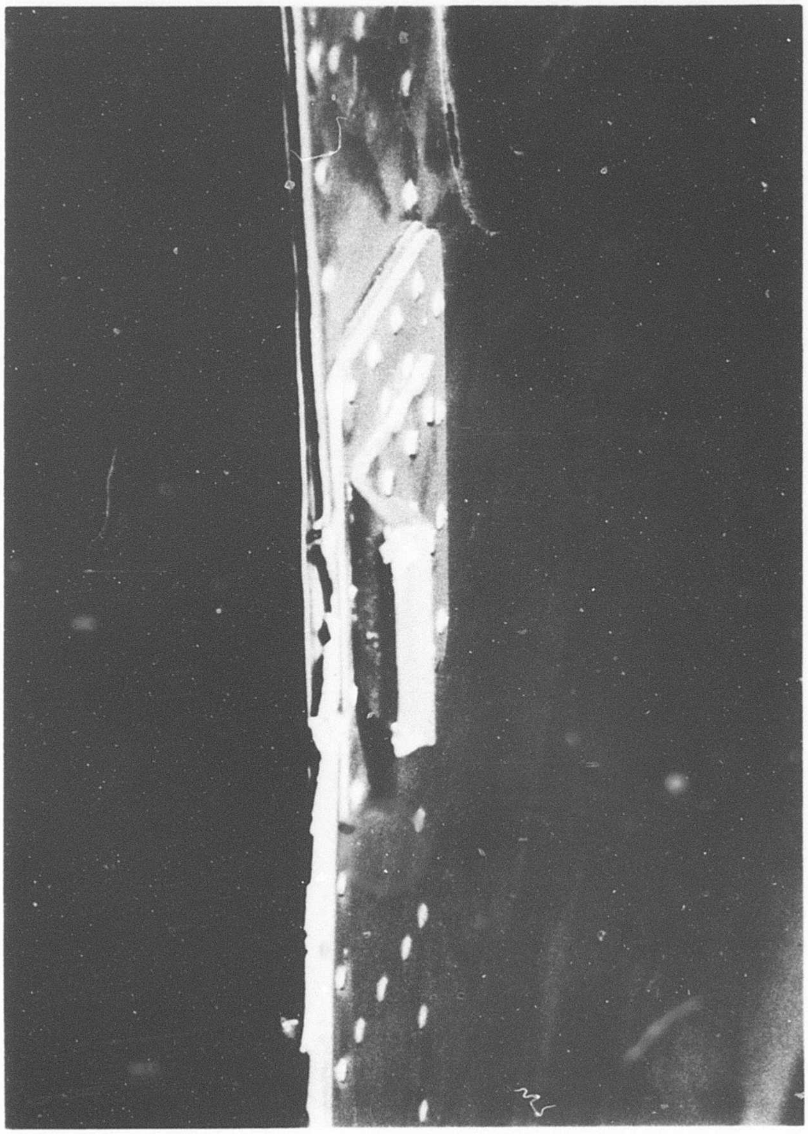


Figure 16. View Showing Deformation of New Striker Plate and Damage to Aft Edge of Door.

have other ramifications in that it would necessitate more stringent requirements for track straightness and parallelism with noncumulative tolerances along its length and would probably require virtually daily attention in service to prevent jamming from dirt and debris accumulations.

Consideration was now given to manufacturing roller housings in different materials. Aluminum was rejected as a substitute since aluminum vs. aluminum can gall more rapidly than steel vs. aluminum. Nylon was briefly considered, but our past experience with this material under vibratory loading conditions has not been conducive to establishing confidence in it. It was also felt that nylon would tend to imbed abrasive particles and act as a grinding wheel as it travelled along the tracks. This could lead to long-term problems with the tracks, which would be much more difficult to correct than a straightforward roller replacement.

Phenolic was the next candidate material for consideration. This material was considered to have the same problem concerning abrasive particle imbedment as did nylon. Additionally, it was felt that phenolic would be more susceptible, in long-term usage, to degradation from contaminative substances such as oils, greases and fuel.

It was thereupon decided that redesign of the roller housings would not be productive, and so this approach was abandoned.

A defect which was not specifically mentioned in the operational data analysis but which showed up in the current design test program was deformation of the door latches (Figure 12). It was evident that the deformation was caused by the latches' striking their detent plates as they moved past them during the open/close cycling of the door. This is another instance of impact damage, which again invokes proposed new design criterion No. 4 for its solution.

The current design latches are flat steel plate sections, and in order to strengthen them, they were converted to Tee-section configurations by welding a cross-bar to their outer vertical edges. The modified latches are shown in Figures 17 and 18.

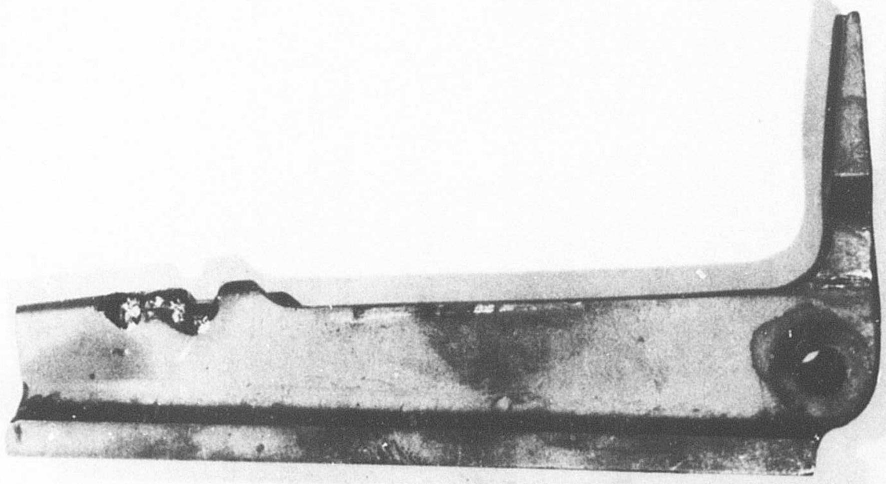


Figure 17. Modified Aft Latch After Test Showing Local Impact Damage.

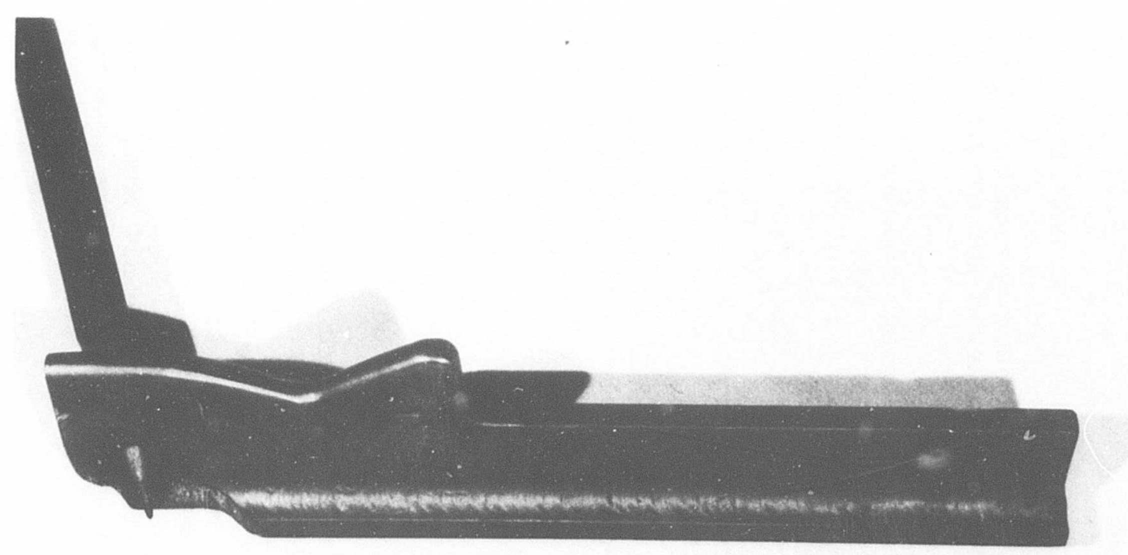


Figure 18. Modified Forward Latch After Test Showing Local Impact Damage.

TEST RESULTS - MODIFIED DESIGN - PILOT RESCUE DOOR

The pilot rescue door with the modified roller spacers and latches and the new external door stop was installed on the static test fuselage, and the test setup used on the current design door was duplicated.

The test blocks used in the original test were repeated, i.e., ten discrete blocks, each consisting of 25 hours of vibratory testing followed by 500 hard open-close cycles. The test and inspection procedures followed the original format in all respects.

Testing commenced and proceeded through the entire test spectrum with little eventful to record. After 175 hours of vibratory testing and 3,000 open-close cycles of door operation, the striker plate mounted at the aft edge of the door was beginning to deflect and bow outward, away from the door structure. This deflection showed some further progression as the test continued, but at the end of the test the stop and striker plate were still operative.

At the conclusion of the test with 250 hours of vibratory testing and 5,000 hard open-close cycles accumulated, no failures had been experienced.

Findings and Conclusions

Upon completion of the test, the door was removed from the test fuselage and subjected to teardown inspection.

The following discrepancies were noted during this inspection:

1. Door striker plate was bowed outboard from the door (but still operative) (Figure 16).

2. The aft upper roller had several minute flat spots. However, these flat spots were not of sufficient size to impair the operation of the door (Figure 19).

3. The sheet-metal fairing on the aft edge of the door had suffered some minor impact damage as a result of (1) above (Figure 16).

4. The plates supporting the rubber bumper on the new door stop had minor impact damage due to a slight discrepancy in waterline heights between the door stop and the door striker plate (Figure 14).

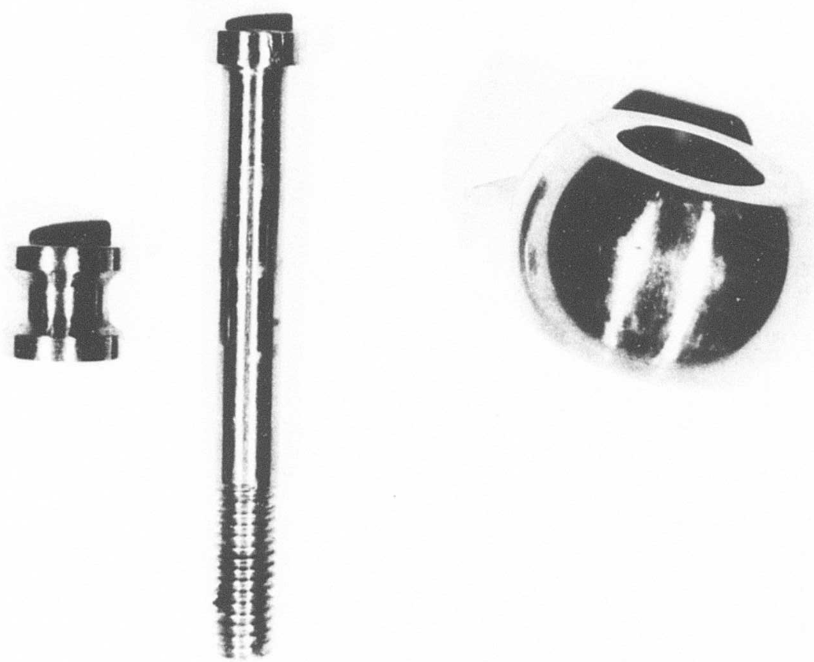


Figure 19. Modified Roller Spacer With Roller Shaft and Bearing Showing Lack of Damage After Test.

All other fittings showed no evidence of damage.

The results from the testing of the door with modified hardware, therefore, showed a very definite improvement over the current design door.

Considered individually, each change is very minor, and yet in total the effect appears to be greater than the sum of the parts. The effects desired to be accomplished by the modifications were:

1. Eliminate bending of roller shafts.
2. Eliminate compression failures of roller spacers with consequent increase of amplitude in door motions.
3. Decrease wear on roller housings.

All these objectives were attained and, particularly with respect to (3), to a degree beyond what was anticipated. On the basis of this test, it would appear that preventing failure of the roller spacers was the most significant contribution of the design changes.

It should be noted that the installation of the new design door stop was in accord with proposed new design criterion No. 6, relating to protection from damage due to impact. This same criterion is also pertinent to the redesign of the door latches.

The failure of the roller spacer showed that it had been caused by vibratory pounding, and so this same impact protection criterion was invoked, along with the admonition in SD-24K, Para. 3.7.1.3.1.1.1, relating to protection from failure due to vibration, in the redesign of the roller spacer.

Since the current design and redesigned doors were subjected to identical tests, the very good results obtained from the latter test would appear to verify the efficacy of investigation and application of new criteria to secondary structure designs in order to enhance their reliability and maintainability.

IMPACT OF TEST RESULTS ON NEW CRITERIA

It was evident from the very good results obtained from the modified design test on the pilot rescue door that the application of proposed new design criterion No. 4 had proven to be most efficacious. It should of course be understood that the

entire test program of vibratory testing and operational cycling of the door essentially fulfills the requirements of proposed new test criteria Nos. 1 and 3.

If these three criteria had been defined and applied when this door was first designed, then the defects of this door would have been uncovered in the pre-production stages and its subsequent service and maintenance history would have been vastly improved. This would seem to verify the validity of the thesis that the reliability and maintainability of secondary structural components can be enhanced by the application of rigidly defined new design and/or test criteria during the design stages of such components.

None of the findings, from either the current design or modified design test programs, have suggested any need for redefinition of the proposed new criteria.

FUSELAGE BOX STEPS

DESCRIPTION OF TEST COMPONENT - FUSELAGE BOX STEPS

These steps are located on each side of the fuselage on the Kaman H-2 helicopter and are recessed into the fuselage. They provide personal access to the helicopter roof area for rotor, drive system and engine servicing. The steps are staggered in adjacent structural bays as defined by fuselage frame spacing. Each step consists of a cutout in the fuselage skin of sufficient size to accommodate personnel footwear. The lower edge of each cutout is bounded by a Z-shaped fuselage stringer. This stringer has a C-shaped channel nested over it to form a box-section in the step area. Attached to the top edge of the skin cutout is a spring-loaded hinged door which is normally in the closed position and which is deflected open when a foot is entered into the step area. Bounding the step cutout is a flanged, light-gage, rectangular box which is riveted to the skin through the flanges. The function of the box is to prevent the ingress of debris into the aft fuselage area.

Details of the current design fuselage box step are shown in Figures 20 and 21.

TEST CONDITIONS - FUSELAGE BOX STEPS

Upon surveying the past experience of these items, it appeared that corrosion contributed to a large proportion of the recorded problems. However, inclusion of corrosion effects was not within the scope of the testing visualized for this program, and so no attempt was made to simulate corrosion. Therefore, because the steps are not affected by rotor-induced vibrations, only actual stepping loads were considered for the test program.

Again, 5,000 flight hours were considered to be the base datum for load spectrum determination. Eight loadings on the step per flight hour was chosen as a realistic estimate of usage.

Number of loadings on step =

5000 (flight hours) X 8 (loadings/hour) = 40,000

It was decided to apply these 40,000 load cycles to simulate a 200-lb man using the steps at a load factor of 1.0g.

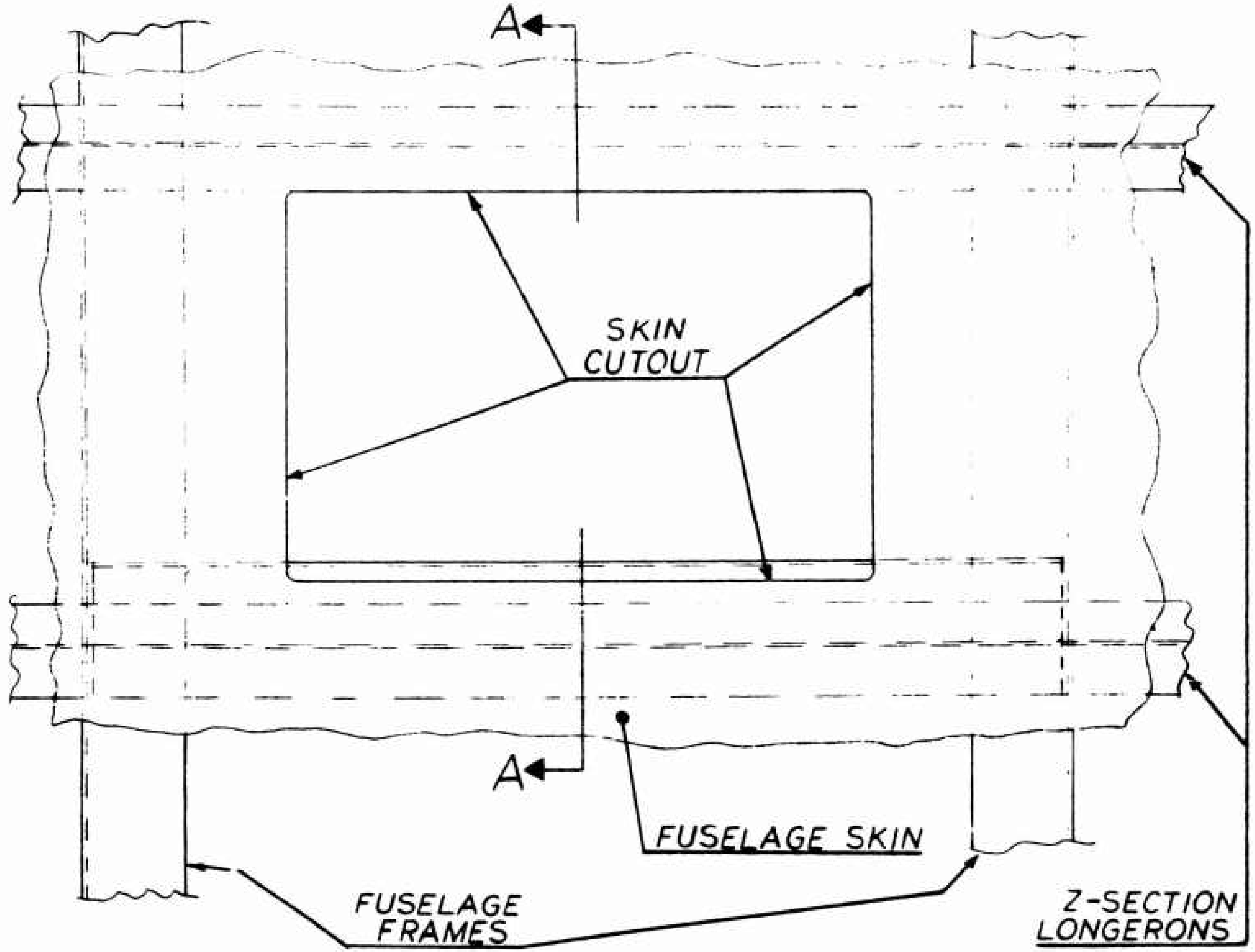


Figure 20. Sketch of Current Design Box Step.

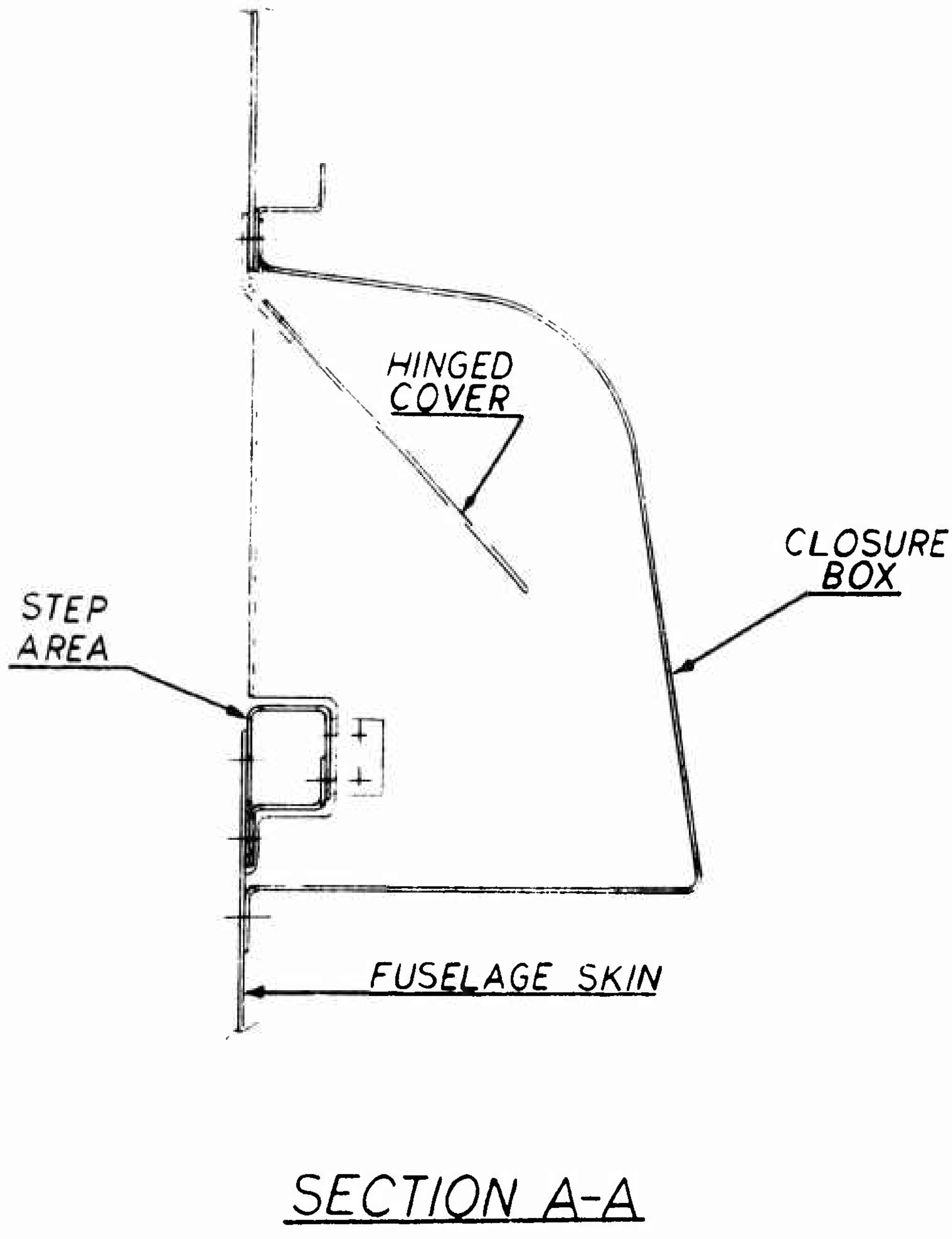


Figure 21. Cross Section of Current Design Box Step.

REDESIGN CONSIDERATION - FUSELAGE BOX STEPS

On the H-2 helicopter static test fuselage there were two box steps suitable for test purposes, one on each side of the fuselage. The step on the left-hand side was refurbished but retained in the current design configuration.

Referring to Figures 20 and 21, it can be seen that the current design is deficient in that it permits the existence of a free edge of the skin cutout in very close proximity to the load-bearing area of the step. This free edge of the thin fuselage skin is very susceptible to scuffing and impact damage. This puts redesign consideration in line with new criteria No. 4, relating to reduction of impact damage on secondary structural components.

Accordingly, the step on the right-hand side was modified by the addition of a doubler to the step area. This doubler is external to the fuselage skin and projects forward and aft beyond the cutout in the skin which forms the box step. The doubler also wraps inboard over the top of the step area. These configurations are illustrated in Figures 22 and 23.

TEST SETUP - FUSELAGE BOX STEPS

An electromechanical device shown in Figures 24 and 25 was designed by Kaman to apply the test loads to the box step. This device, which has a rubber composition pad on the load-bearing area similar to a boot sole, simulates reasonably closely the foot action of a man climbing on the steps. The kinematics of the mechanism are such that the load bearing pad is entered into the step cutout, scuffs lightly inboard, applies a downward load on the step area, rotates "toe-down" under this load, and then scuffs lightly outboard to complete a load cycle. The load application capability of this device is adjustable from 0 to 300 lb and is monitored by means of an SR-4 strain recorder hooked up to strain gages on a calibrated link. On the current design step test, the linkage was adjusted so that the load was applied vertically; but in the modified design test, the load was applied at an angle of 4° to 5° outboard from vertical, thus applying an inboard (and out-of-plane) load component. This is in accord with proposed new criterion No. 9.

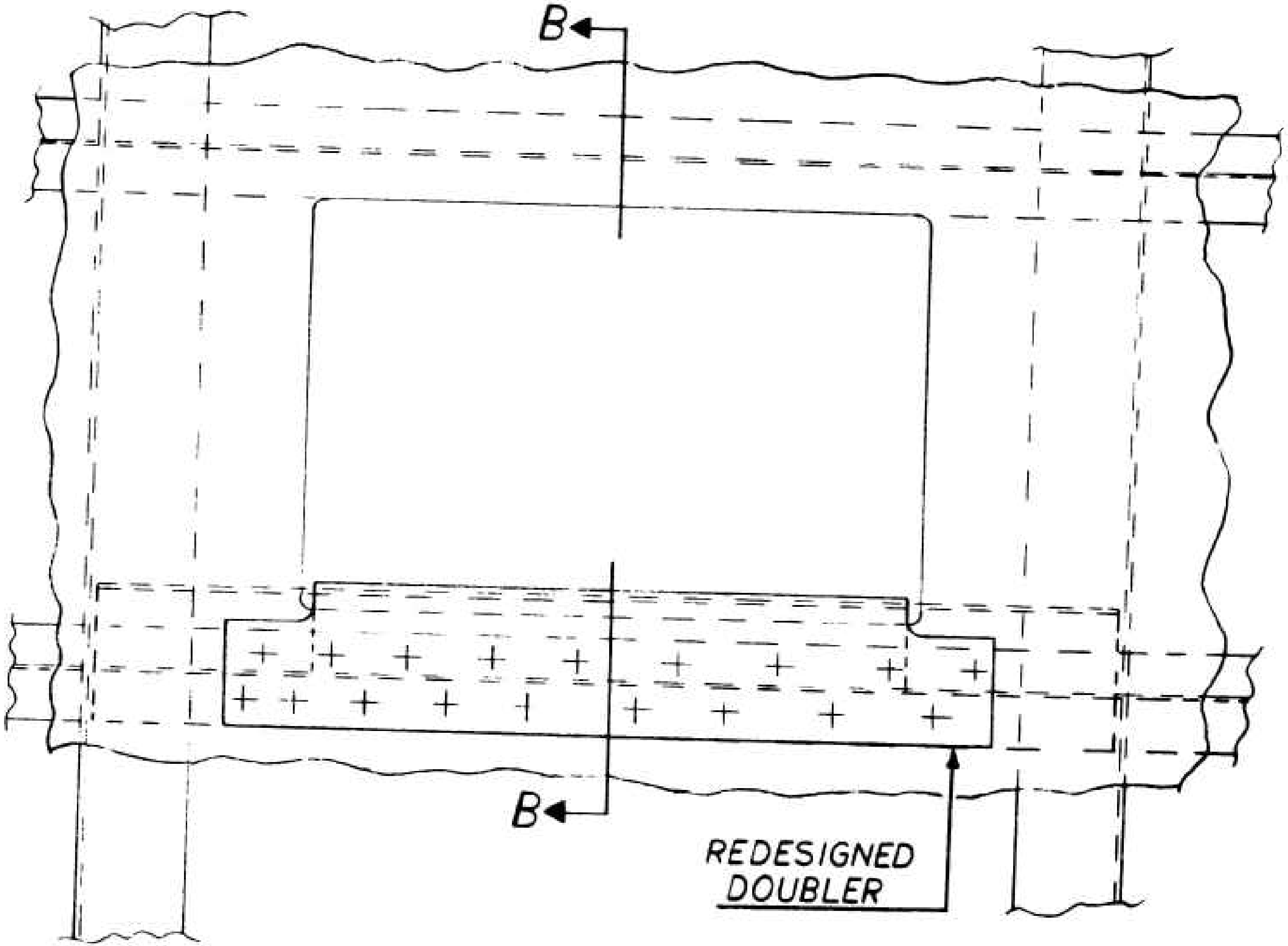


Figure 22. Sketch of Modified Design Box Step.

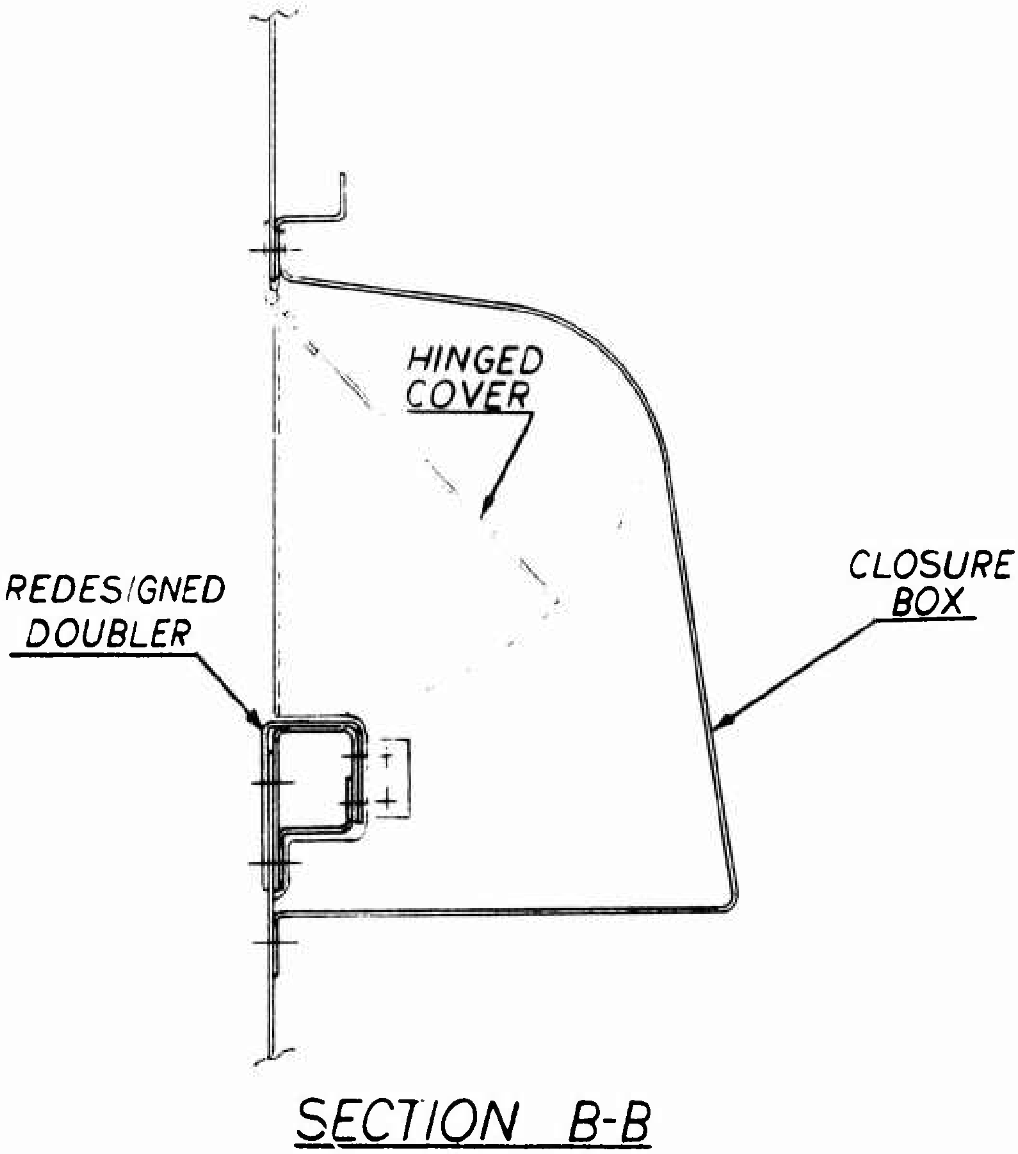


Figure 23. Cross Section of Modified Design Box Step.

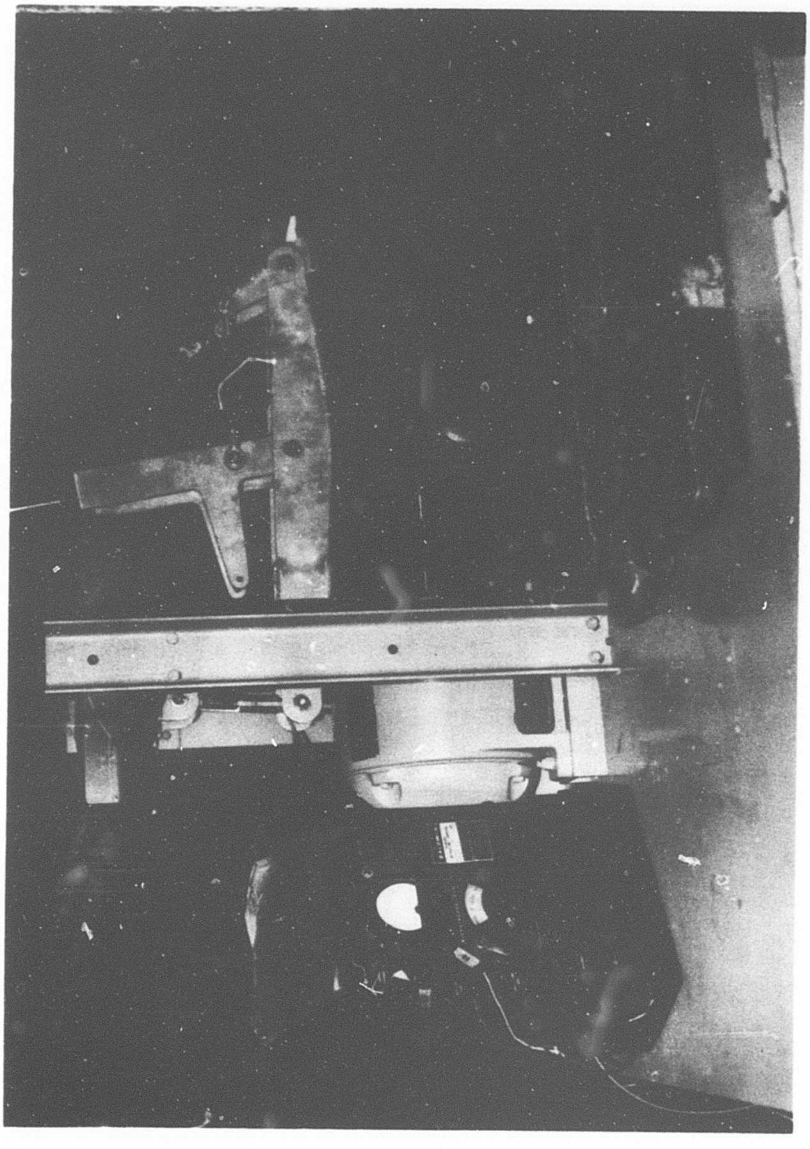


Figure 24. Test Setup on Box Step.

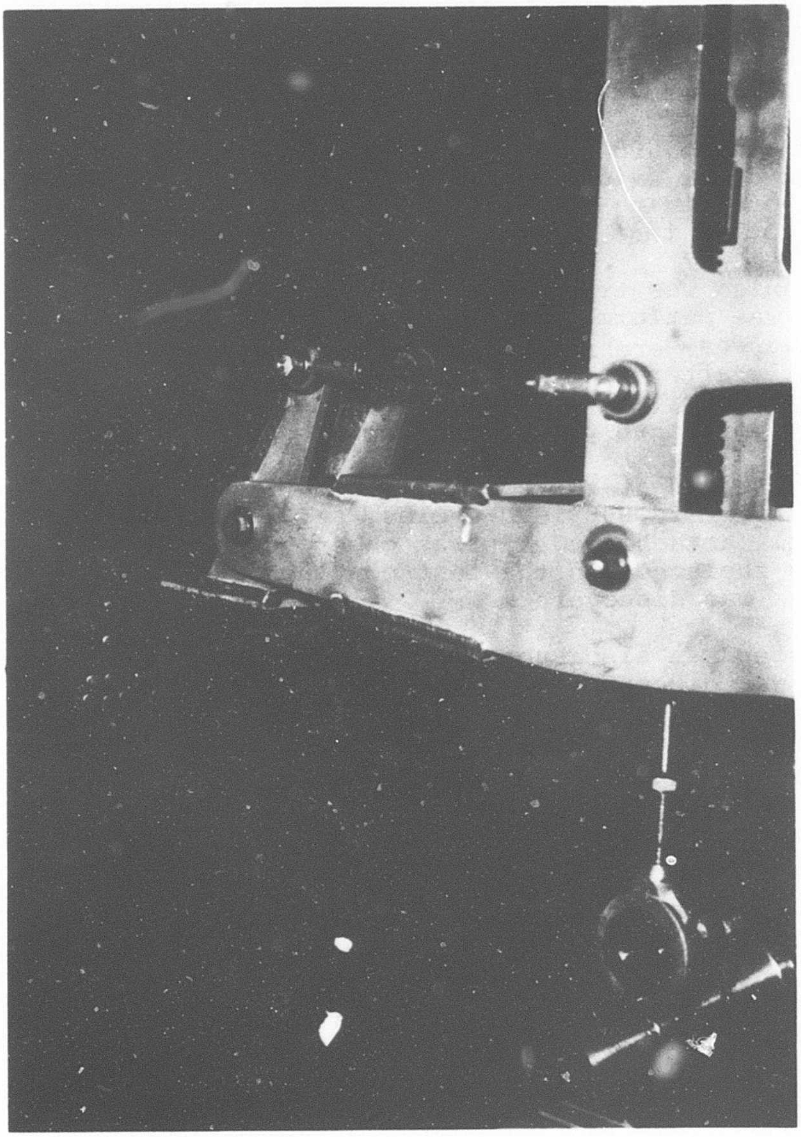


Figure 25. Close-Up View of Box Step Test.

TEST PERFORMANCE AND FINDINGS - FUSELAGE BOX STEPS - CURRENT AND REDESIGNED COMPONENTS

The loading device was set up on the left-hand side of the test fuselage to test the current design step. The load level was adjusted to 200 lb and the test commenced.

At the end of each 5,000 load cycles, the step area was thoroughly inspected for evidence of damage. The step accumulated 40,000 cycles of loading at the 200-lb load level with no evidence of wear other than scuffing of the paint finish.

The test mechanism was transferred to the right-hand side, and the same test was performed on the modified box step. The inspection procedures were repeated after each 5,000 load cycles, and additionally after 40,000 cycles the redesign doubler was carefully removed for inspection of underlying structure. Again, nothing more than paint scuffing was observed.

The test was repeated at the 250-lb load level on the current design step. After 20,000 load cycles, a 1/8-in.-diameter rivet in a small attachment clip was observed to be loose. This rivet was replaced and the test continued to 40,000 cycles. No other damage was discovered.

The modified step was also subjected to the 250-lb load cycling and no damage was discerned.

Finally, both steps were subjected to 40,000 cycles of loading at the 300-lb level, and once more, no damage was discovered.

Findings and Conclusions

After the current and modified design steps had each been subjected to 40,000 cycles of loading at the three load levels of 200 lb, 250 lb and 300 lb with no failures in either component, it was reluctantly concluded that continuation of this test at any higher level of loading would not be entirely reasonable.

It is postulated that the field-experienced failures (which were not corroborated in this test) resulted from the following causes:

1. Corrosion between the fuselage skin and the step structure weakens the step area. This was not simulated in the test program.

2. Some unforeseen large component of inboard load is frequently applied to the step area during service use. Note that the modified design step was subjected to a loading which was 4° to 5° off vertical, thus inducing a small inboard load component.

In summary, this test corroborated neither the field experience with the steps nor the validity of the new criteria.

FAILURE MODE AND EFFECTS ANALYSIS FOR SECONDARY STRUCTURES

GENERAL

The Failure Modes and Effects Analysis (FMEA) is a basic analytical tool for design evaluation and reliability improvement. The usual objective of an FMEA is to highlight critical failure areas of a given design that have a serious effect on successful completion of the designated mission and on crew safety, so that susceptibility to these failures may be removed from the system. In this investigation, the purpose of the FMEA is to determine whether the analysis correlates with service experience on the selected components and thus the usefulness of specifying FMEA for new design of selected secondary structure components. The analysis consists of methodically itemizing and evaluating components of the selected units in terms of potential failures, based on empirical knowledge of the hardware design. If the weakness or limitations of existing hardware can be pinpointed by following this analytical approach, then the FMEA technique may be useful in directing appropriate engineering attention toward improving critical reliability areas of new secondary structure designs.

METHODOLOGY

The methodology followed in performing the FMEA is shown schematically in the workflow diagram of Figure 26. A functional analysis of each selected secondary structure unit is coupled with empirical knowledge of the design and detailed drawings of the unit and its components to provide the basis for preparing a reliability block diagram. The reliability block diagram is essentially a logic chart showing the systematic arrangement of subassemblies and components of the unit that must operate successfully in order for the unit to perform its design function. These diagrams aid in itemizing the component parts of the design, as well as isolating those components whose operation is critical to the functional capability of the design and eliminating from the analysis those components which are of minor importance relative to reliable performance of the unit.

Once the critical components are isolated and itemized, the analysis evaluates each of these in turn to establish possible modes of failure, cause of failure, effect of failure on operation of the unit, and an estimate of the relative frequency of occurrence of likely failure modes. The analysis also develops and exposes the types of failures that can occur for the secondary structure unit and its subassemblies. These can include pure failures, such as overloads causing structural failure,

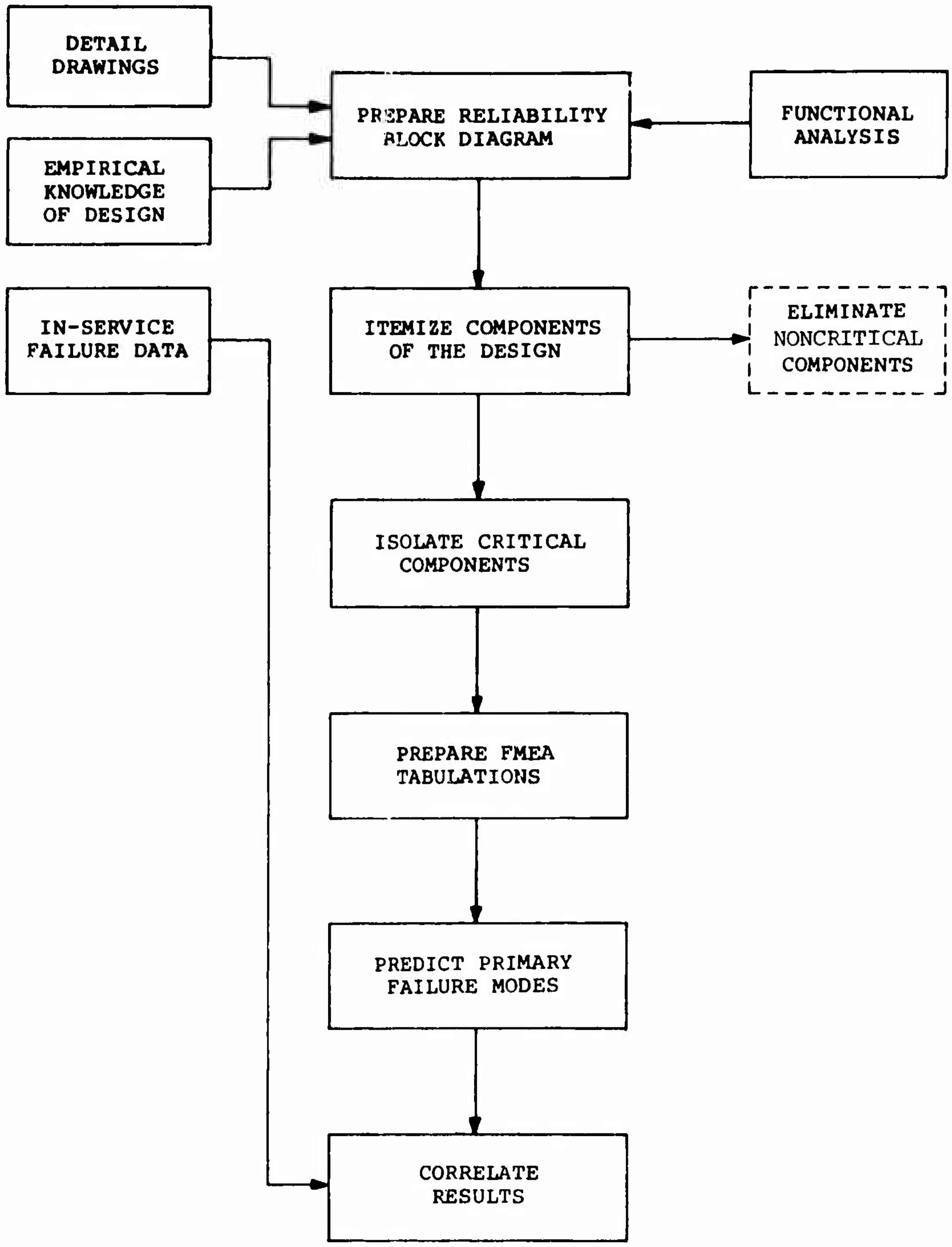


Figure 26. FMEA Workflow Diagram.

as well as failures due to the operating environment such as extreme heat, cold, ice and/or dirt, likely abuse resulting from location on the aircraft, and secondary failures due to the effects of other components or the presence of oils, acids or other corrosive agents.

The FMEA data are tabulated using a standard format developed specifically for this purpose. The types of information reported are as follows:

1. Part Name, Part Number - Each component is given a line entry using the identification and description given on the applicable drawing or parts list.

2. Assumed Failure - The most likely failure modes are indicated. For each component, every reasonable possible failure mode is considered.

3. Possible Cause - The probable or most likely causes of each assumed failure are identified.

4. Failure Effect - The effect upon both components performance and unit operation due to the indicated failure mode is identified. Particular notice is taken of any sequential effects that might be induced by the failure mode under consideration.

5. Detection Method - An indication of how the failure can be detected is given, such as visual inspection, unusual vibration, noise, etc.

6. Compensating Features - Any compensating design features or inspection techniques available to counteract the effect of a failure are listed.

7. Criticality Code and Failure Class - Failures are categorized as to probable effect on safety and mission success, and analyzed qualitatively as to probability of occurrence.

The following code is used for defining criticality in accordance with MIL-STD-882:

Category I - Safe - Little or no performance degradation but requires corrective action during routine maintenance.

Category II - Marginal - Some performance degradation and possible mission abort without major damage or injury to personnel.

Category III - Critical - Mandatory Abort - Potential injury to crew and material damage to aircraft.

Category IV - Catastrophic - Potential fatalities and probable loss of aircraft.

The following subjective classifications are used to provide a qualitative estimate of the probability of occurrence of failures:

A - Probability of failure is much higher than normal.

B - Probability of failure is above normal.

C - Probability of failure is normal; failures are rare.

D - Probability of failure is below normal; failures are not expected in service.

In general, component parts of a well-designed unit are expected to exhibit failure frequencies grouped within the C and D classifications. Although A or B failure classifications might be assigned occasionally to one or two critical components of a design subjected to severe use, these classifications usually indicate an inherent design inadequacy or weakness, or suggest some deficiency in the component itself.

In addition to these frequency of occurrence estimates, each assumed failure is categorized as to time dependency using the following code:

R - The failure is random in nature and is assumed to be independent of the total operating time.

T - The failure is time-dependent and, therefore, is expected to occur with increasing frequency as the operating time increases.

As a result of the failure modes and effects analysis, all types of failures that might occur for the selected secondary structure units and their components are exposed and tabulated. From this it is possible to develop a qualitative estimate of critical component failure occurrences. The predicted failures of the FMEA can then be compared to reported actual in-service failure data.

If good correlation is obtained between predicted and actual failures, the effectiveness of this method for predicting primary failure modes of secondary structures will have been demonstrated. On the other hand, if only moderate or

unsatisfactory correlation is obtained, it should be possible to understand the reasons for any lack of validity of the FMEA and to apply this understanding to future analyses of new designs.

Initially, consideration was given to predicting quantitative values of component failure rates for the secondary structure items evaluated during the program. However, this approach was eventually discarded because of the very limited statistical data base of mechanical component failures and the extensive analysis required to compute failure rates whose validity could not be readily verified.

SELECTED SECONDARY STRUCTURES

Two secondary structure items of the H-2 helicopter have been selected for detailed evaluation: the pilot/rescue door and the fuselage box step. The pilot/rescue door has experienced a relatively high incidence of in-service damage/failure reports and is a frequent cause of aircraft grounding because of its required rescue function. For these reasons, this door unit offers the greatest potential for a detailed failure modes and effects analysis among all H-2 secondary structures. The fuselage box step, on the other hand, is considered to be the only suitable non-door H-2 secondary structure subjected to severe service use.

The reliability block diagram prepared for the pilot/rescue door unit is shown in Figure 27. For the purposes of this investigation the door unit has been divided functionally into three basic assemblies: the handle/latch assembly, the upper roller assembly, and the lower roller assembly. A fourth assembly of the door unit which includes the door structure, windows, and seals was not evaluated during this program and has been omitted from the reliability block diagram. A failure modes and effects analysis has been performed for each of the three pilot/rescue door assemblies indicated in Figure 27. In addition, separate FMEA's have been prepared for two critical subassemblies: the door jettison subassembly and the lanyard subassembly.

Figure 28 shows the reliability block diagram constructed in preparation for the box step assembly FMEA. Only the box and the step are critical to proper functioning of the assembly.

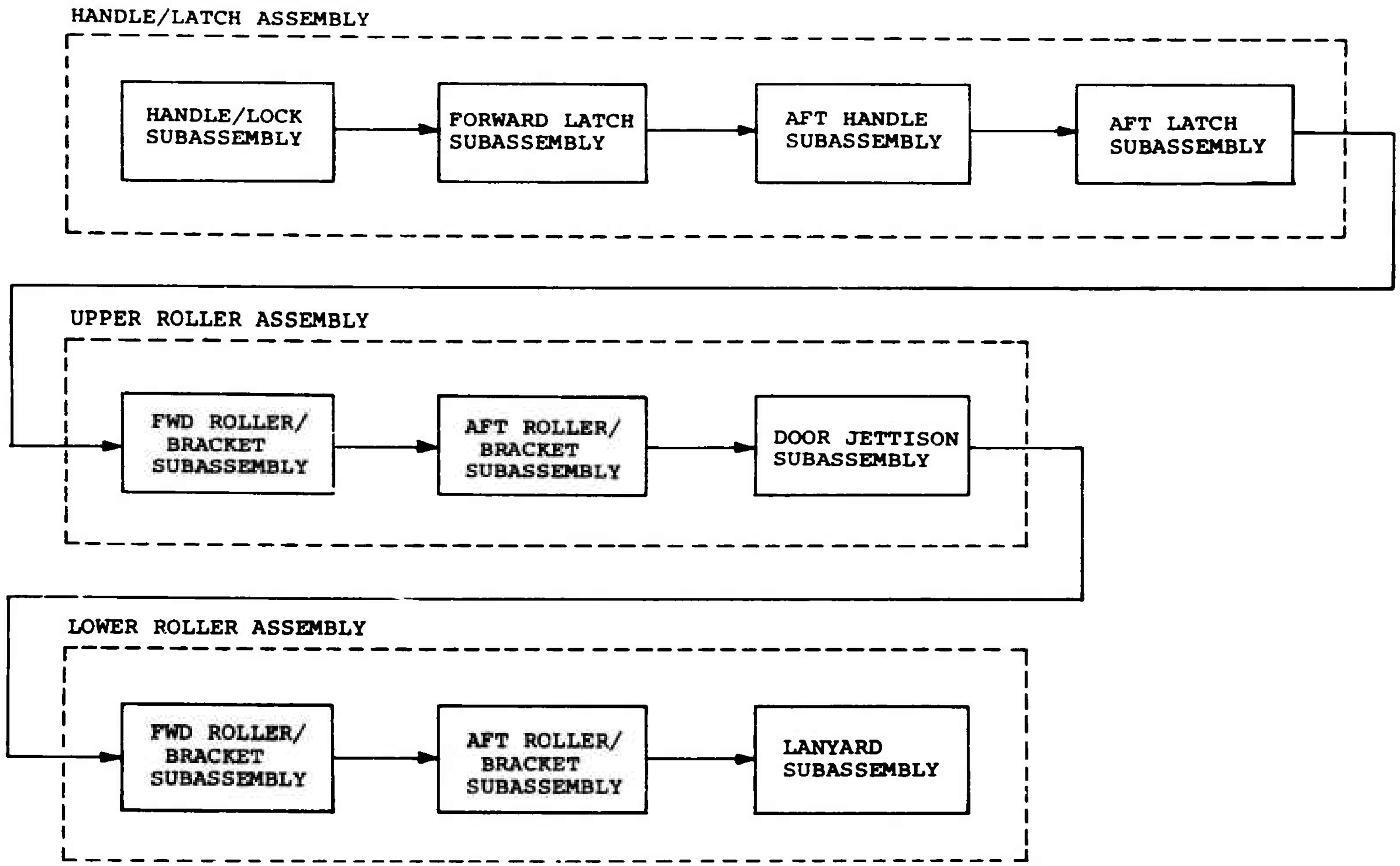


Figure 27. Pilot Rescue Door Reliability Block Diagram.

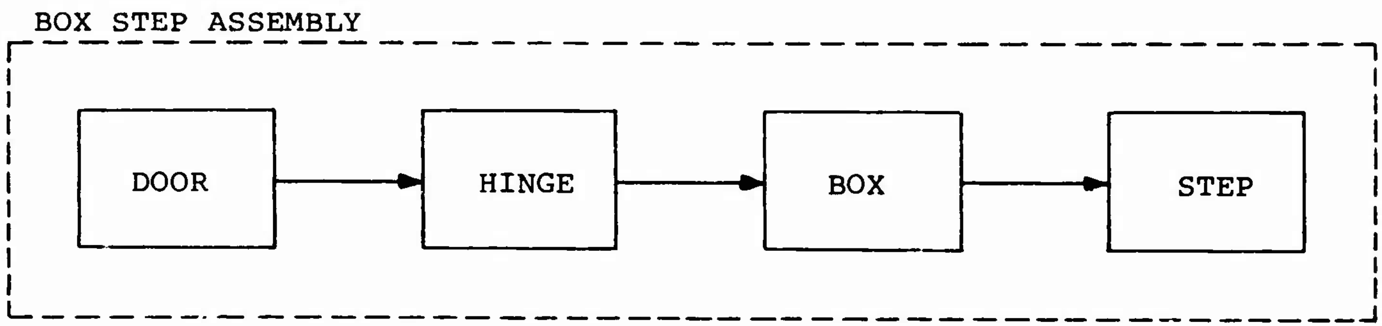


Figure 28 . Box Step Reliability Block Diagram.

RELIABILITY ANALYSIS RESULTS

Handle/Lock Assembly

A detailed parts breakdown of the pilot/rescue door handle/lock assembly is shown in Figure 29. For convenience in conducting the analysis, the assembly was divided into four functional subassemblies. Tables II through V present detailed parts lists for each of the four subassemblies, indicating the criticality code, failure probability class, and failure type, as well as denoting those parts which are critical to the successful operation of the handle/lock assembly. The failure modes and effects analysis (FMEA) was performed at the component level for all parts critical to assembly operation. The results of this analysis are shown in Table VI.

These data have been used to obtain a rough quantitative estimate of the percentage of expected failures associated with each of the assumed failures tabulated. This was accomplished in the following manner:

1. All assumed failures were grouped into four general categories.

   Broken/Bent Parts
   Misaligned/Worn Parts
   Corroded/Unlubricated Parts
   Loose Parts

2. Each assumed failure entered in the FMEA table was weighted according to the failure probability class assigned to that entry, with a weight of one for class C, two for class B, four for class A and one-half for class D (each failure probability class is given twice the weight of the next lower class).

3. In cases where the assumed part failure indicated might possibly be caused by a preliminary undetected failure of another part, such as a bent part resulting from a misaligned part in the linkage, the weighted value for that table entry was divided between the two failure categories involved.

4. The sum of the weighted values for each failure category was divided by the sum of the weighted values of all failures listed in the FMEA table to evaluate the fraction of total assumed failures falling within each of the four categories.

5. It was assumed that the tabulated failures account for approximately 67 percent of all failures that would be experienced in actual operations, so that the percentage of total assembly failures predicted for each of the four failure categories is the product of this 67 percent and the fraction of assumed failures falling within the category. Primary failure modes usually account for 60 to 70 percent of total failures reported in field data.

Using this procedure, the following predicted values were computed for the most probable causes of operational failures of the handle/lock assembly:

Broken/Bent Parts	33%
Misaligned/Worn Parts	23%
Corroded/Unlubricated Parts ..	8%
Loose Parts	3%

Table VII presents an assembly level FMEA for the handle/lock assembly which was prepared on the basis of the component parts level FMEA of Table VI. Table VII lists functional failure modes predicted for the handle/lock assembly where the possible causes tabulated correspond to the assumed parts failures of Table VI. It is seen in Table VII that the most probable mode of failure for the handle/lock assembly is binding of the mechanism, with jamming of the mechanism and extensive slop in the mechanism also being important failure modes.

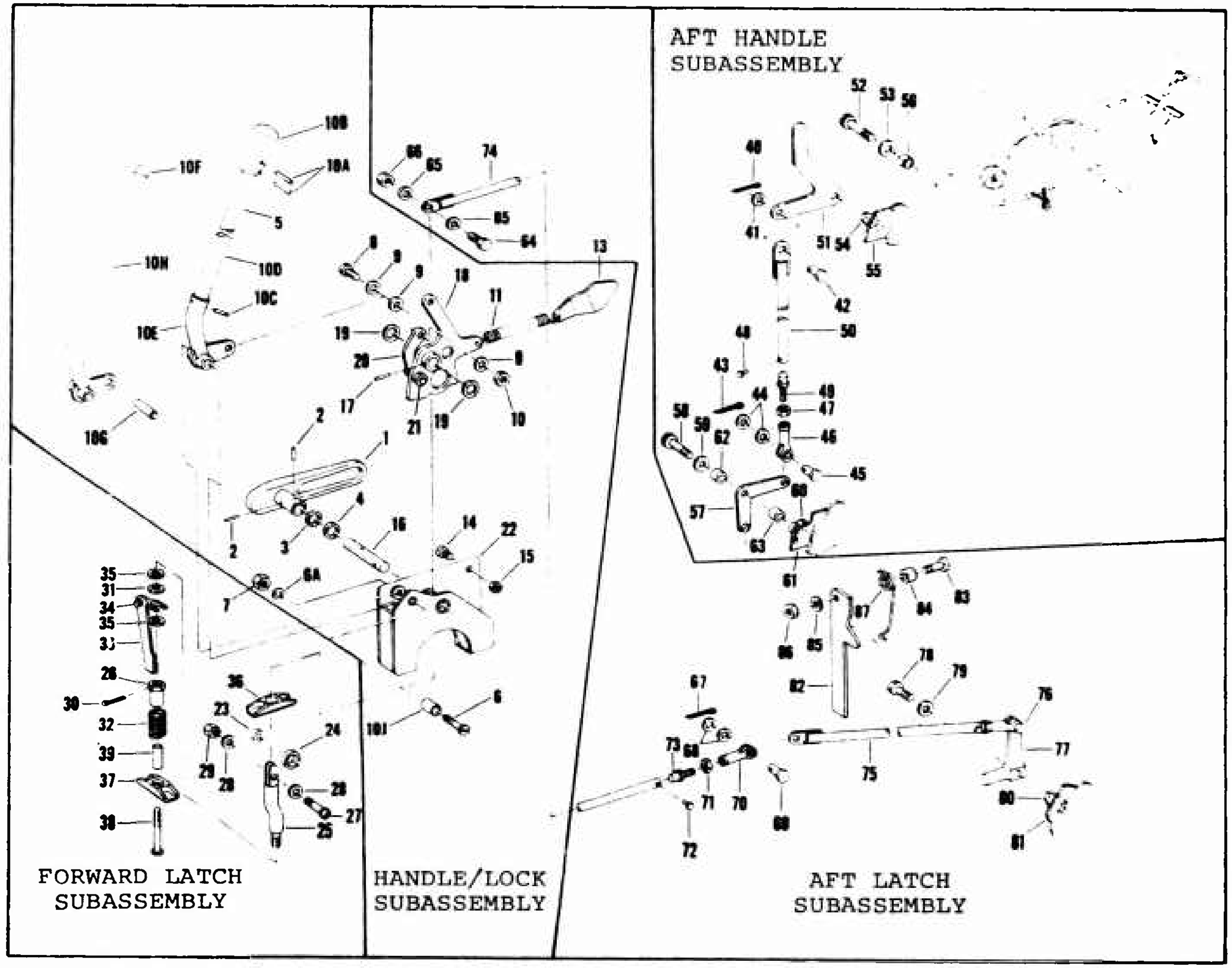


Figure 29. Parts Breakdown, Handle/Latch Assembly.

TABLE II. DETAILED PARTS LIST - PILOT RESCUE DOOR, HANDLE/LATCH AND FORWARD HANDLE/LOCK

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
*	18-1	Handle, Outer	1	I	C	T
	18-2	Pin, Spring	2	I	C	R
	18-3	Washer	1	I	D	R
*	18-4	Seal	1	I	B	T
	18-6	Screw	1	I	D	R
	18-6A	Washer	1	I	D	R
	18-7	Nut	1	I	D	R
	18-8	Screw	1	I	D	R
	18-9	Washer	3	I	D	R
	18-10	Nut	1	I	D	R
	18-10F	Cap, End	1	I	C	T
	18-10G	Bushing	1	I	C	T
*	18-10H	Handle Weldment	1	I	C	T
	18-10J	Bushing	1	I	C	T
*	18-11	Spring	1	II	C	T
	18-13	Bracket	1	I	D	R
	18-14	Screw	3	I	D	R
	18-15	Nut	3	I	D	R
*	18-16	Shaft	1	I	C	T
	18-17	Pin, Spring	1	I	C	R
*	18-18	Cam Weldment	1	II	B	R
	18-19	Washer	2	I	D	R
*	18-20	Link	1	I	B	R
	18-21	Screw	1	I	D	R
		Washer	3	I	D	R
		Nut	1	I	D	R
	18-22	Lock Box	1	II	D	R
		Bushing	2	I	C	R
		Bushing	2	I	C	R

TABLE III. DETAILED PARTS LIST - PILOT RESCUE DOOR, HANDLE/LATCH AND FORWARD LATCH

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	18-23	Bushing	1	I	C	T
*	18-24	Roller, Door Latch	1	II	C	T
	18-25	Plunger	1	II	D	R
	18-26	Turnbuckle	1	II	D	R
	18-27	Screw	1	II	D	R
	18-28	Washer	2	I	D	R
	18-29	Nut	1	II	D	R
	18-30	Pin, Cotter	1	I	C	R
	18-31	Washer, Flat	1	I	D	R
*	18-32	Spring, Plunger	1	II	C	T
*	18-33	Latch Weldment	1	II	C	T
	18-34	Bolt	1	II	C	R
		Washer	2	I	D	R
		Nut	1	II	D	R
		Pin, Cotter	1	I	C	R
	18-35	Washer, Flat	2	I	D	R
	18-36	Guide, Plunger	1	I	D	R
	18-37	Guide, Plunger	1	I	D	R
	18-38	Screw	1	I	D	R
	18-39	Spacer	1	I	C	T

TABLE IV. DETAILED PARTS LIST - PILOT RESCUE DOOR, HANDLE/LATCH AND AFT HANDLE

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	18-40	Pin, Cotter	1	I	C	R
	18-41	Washer	1	I	D	R
	18-42	Pin, Flat Head	1	I	D	R
	18-43	Pin, Cotter	1	I	C	R
	18-44	Washer	2	I	D	R
	18-45	Pin, Flat Head	1	I	D	R
	18-46	Clevis, Rod End	1	I	D	T
	18-47	Nut	1	I	D	R
	18-48	Rivet	2	I	C	R
	18-49	Rod End	1	I	D	R
*	18-50	Rod, Connecting	1	I	C	T
*	18-51	Handle	1	I	C	T
	18-52	Bolt	1	I	C	R
	18-53	Washer	1	I	D	R
	18-54	Nut, Plate	1	I	D	R
	18-55	Plate	1	I	D	R
	18-56	Spacer	1	I	C	T
	18-57	Crank	1	I	C	T
	18-58	Bolt	1	I	D	R
	18-59	Washer	1	I	D	R
	18-60	Nut	1	I	D	R
	18-61	Plate	1	I	D	R
	18-62	Spacer	1	I	C	T
	18-63	Spacer	1	I	C	T

TABLE V. DETAILED PARTS LIST - PILOT RESCUE DOOR, HANDLE/LATCH AND AFT LATCH

Critical Component	Part Ident	Part Description	No. of Each	Crit Code	Fail Prob	Fail Class
	18-64	Screw	1	II	D	R
	18-65	Washer	2	I	D	R
	18-66	Nut	1	II	D	R
	18-67	Pin, Cotter	1	II	C	R
	18-68	Washer	2	I	D	R
	18-69	Pin, Flat Head	1	II	D	R
	18-70	Clevis, Rod End	1	II	D	T
	18-71	Nut	1	II	D	R
	18-72	Rivet	2	II	D	R
	18-73	Rod End	1	II	D	R
*	18-74	Rod, Connecting	1	II	C	T
*	18-75	Rod, Connecting	1	II	C	T
	18-76	Pin, Cotter	1	II	C	R
		Washer	1	I	D	R
		Pin, Flat Head	1	II	D	R
		Clevis, Rod End	1	II	D	T
		Nut	1	II	D	R
		Rivet	2	II	D	R
		Rod End	1	II	D	R
*	18-77	Bellcrank	1	II	D	T
	18-78	Bolt	1	II	D	R
	18-79	Washer	1	I	D	R
	18-80	Nut, Plate	1	II	D	R
	18-81	Doubler	1	II	D	R
*	18-82	Latch, Intermediate	1	II	C	T
	18-83	Bolt	1	II	D	R
	18-84	Bushing	1	I	C	T
	18-85	Washer, Flat	1	I	D	R
	18-86	Nut	1	II	D	R
*	18-87	Spring	1	II	C	T

TABLE VI. FMEA FOR HANDLE/LOCK COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
18-1	Handle, outer	Broken	Overstressed from rough handling.	Door cannot be opened from outside.	Two inside handles will operate door.	I, C, T
18-4	Seal	Worn Deteriorated	Handle usage. Exposure to elements.	Seal leaks allowing water, dirt and other contaminants to enter lock mechanism can lead to lock seizure or binding.	Visual inspection will reveal seal failure before door operation is affected.	I, B, T
18-10H	Handle weldment	Broken	Overstressed from rough handling.	Door cannot be opened using pilot's handle.	Outside & aft handles will operate door.	I, C, T
		Bent	Overstressed from rough handling or linkage misalignment.	Door difficult to operate. May cause excessive wear of lock mechanism.	Outside & aft handles may operate door.	I, C, T
18-11	Spring	Broken	Overstressed from linkage misalignment.	Removal of tension from lock mechanism causes slop in handle/latch assembly. Vibration during flight could lead to latch failure.	Holding door handle will counteract slop. Handle/latch rattle will indicate need for corrective maintenance before more serious failure results.	II, C, T

TABLE VI. Continued

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
18-16	Shaft	Corroded	Water, dirt, etc., leaking through seal (see 18-4).	Shaft binding against lock box bushings makes door difficult to operate using outer handle.	Inside handles may operate door more easily.	I, C, T
18-18	Cam Weldment	Bent	Overstressed from linkage misalignment.	Binding of lock mechanism makes door difficult to operate.	Difficult door operation shows need for corrective maintenance.	II, B, R
18-20	Link	Bent	Overstressed from linkage misalignment or rough handling.	Pilot's handle binds making door difficult to operate.	Aft & outer handles will operate door.	I, B, R
18-24	Roller, door latch	Worn	Misalignment of roller with cam.	Forward latch mechanism subjected to excessive wear which can lead to slop in latch.	Regular inspection will reveal roller wear before serious failure results.	II, C, T
18-32	Spring, plunger	Broken	Fatigue.	Slop results in forward latch which could lead to latch failure in flight.	Latch rattle indicates need for corrective maintenance.	II, C, T
18-33	Latch weldment	Bent	Binding or jamming from misalignment.	Forward latch may not secure door.	Intermediate latch will secure door.	II, C, T

TABLE VI. Continued

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
18-50	Rod, connecting	Bent	Misalignment & rough handling.	Aft handle mechanism binds, may not operate lock.	Forward & outer handles may be used.	I, C, T
18-51	Handle, aft	Bent	Overstressed from linkage misalignment.	Handle may not operate lock.	Forward & outer handles may be used.	I, C, T
		Loose	Worn at pivot point.	Linkage may not operate lock.	Forward & outer handles may be used.	I, C, T
18-57	Crank	Binds	Linkage misalignment.	Lock will not operate.	Forward & outer handles may be used.	I, C, T
18-74 18-75	Rod, connecting Rod, connecting	Bent	Misalignment and rough handling.	Intermediate latch may not secure door.	Forward latch will secure door.	II, C, T
18-77	Bellcrank	Binds	Linkage misalignment.	Intermediate latch may not secure door.	Forward latch will secure door.	II, D, T
18-82	Latch, intermediate	Bent	Binding or jamming from misalignment.	Intermediate latch may not secure door.	Forward latch will secure door.	II, C, T
18-87	Spring	Broken	Fatigue.	Intermediate latch will not secure door.	Forward latch will secure door.	II, C, T

TABLE VII. FMEA FOR HANDLE/LOCK ASSEMBLY

Mode of Failure: Appearance or Behavior	Mode of Failure: Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
Inoperative, jammed	Broken/bent parts.	Door cannot be latched or unlatched, handles will not move, or move without operating lock mechanism.	Other doors can be used for egress. If unlatched in flight, must be held in closed position.	II, C, T
Mechanism binds	Broken/bent parts. Parts misaligned. Parts corroded.	Door can be latched and unlatched only with difficulty. Excessive force required to move handles and operate lock mechanism.	Other doors can be used, if needed. Binding shows maintenance required.	II, B, T
Mechanism loose and sloppy	Worn parts.	Door can be latched and unlatched, but excessive play is noted in handles and latches.	Excessive door rattle or vibration will indicate need for corrective maintenance before more serious failure results.	II, C, T

Upper Roller Assembly

Figure 30 shows the detailed parts breakdown of the upper roller assembly, consisting of the forward roller/bracket subassembly and the aft roller/bracket subassembly. Close examination of Figure 30 reveals that the two subassemblies are identical except for the support brackets and the serrated washers used with the aft bracket to allow vertical door adjustment. This commonality of components is reflected in the detailed parts list, Table VIII, where only one entry appears for parts which are used in both the forward and aft roller/bracket subassemblies.

The results of the component level FMEA are presented in Table IX for all parts judged critical to proper operation of the upper roller assembly as noted in Table VIII. These results have been used as the basis for estimating the percentage of expected upper roller assembly failures attributable to each of the tabulated assumed failures, following the procedure outlined previously in discussing results of the handle/lock assembly reliability analysis.

The values computed for the most probable causes of operational failures are:

Broken/Bent Parts	30%
Misaligned/Worn Parts	22%
Corroded/Unlubricated Parts ...	7%
Loose Parts	7%

An assembly level FMEA for the upper roller assembly is presented in Table X. The functional failure modes listed are predicted for the upper roller assembly based on the assumed parts failures of Table IX. Loose rollers appear to be the most probable mode of failure for the upper roller assembly, while broken rollers and rollers out of alignment are also significant failure modes.

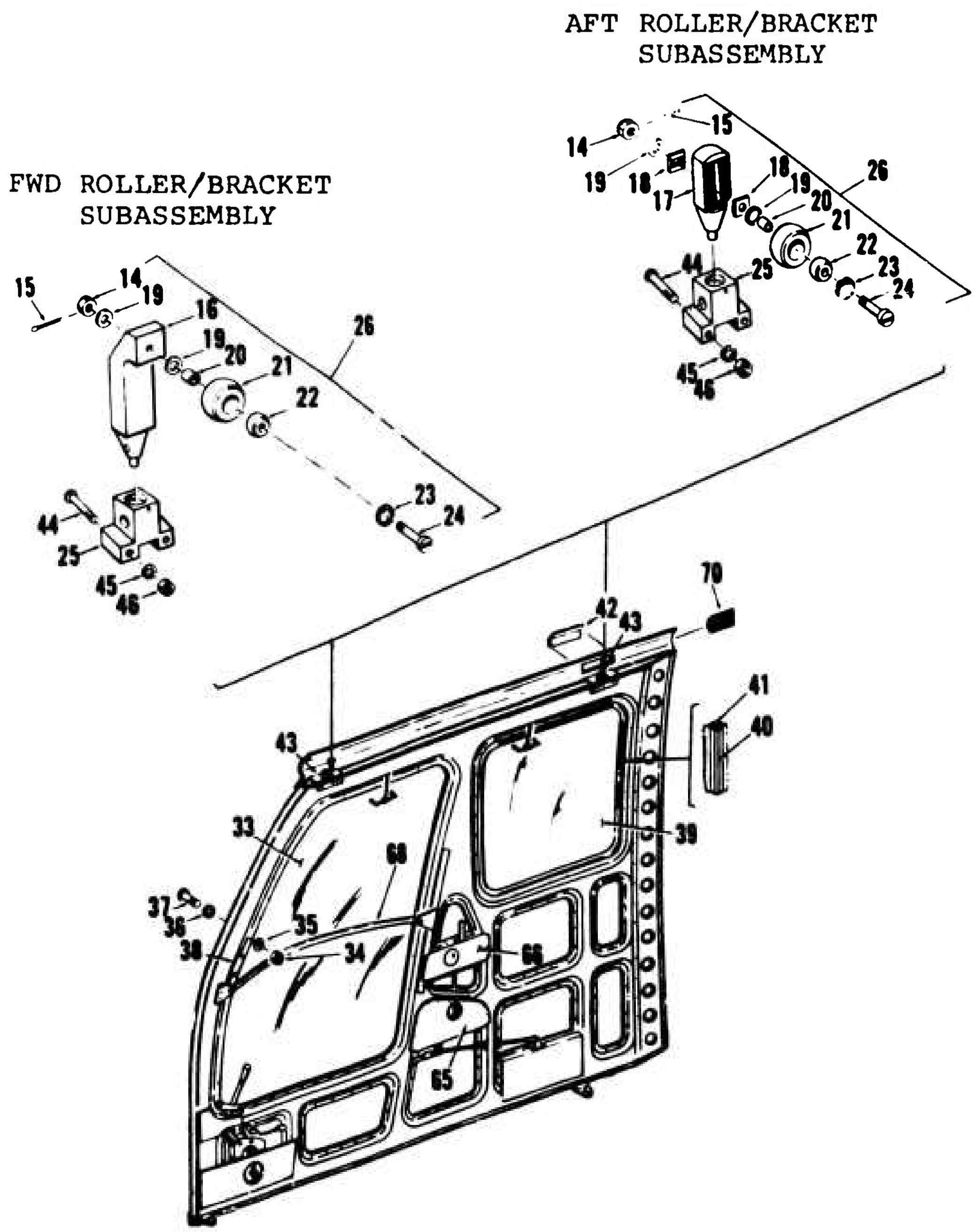


Figure 30. Parts Breakdown, Upper Roller Assembly.

TABLE VIII. DETAILED PARTS LIST - PILOT RESCUE DOOR, UPPER FORWARD AND AFT ROLLER/BRACKET SUBASSEMBLIES

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	4-13-14	Nut	2	III	D	R
	4-13-15	Pin, Cotter	2	II	C	R
	4-13-16	Support Bracket, Forward	1	III	D	R
	4-13-17	Support Bracket, Aft	1	III	D	R
	4-13-18	Washer, Serrated	2	II	D	R
	4-13-19	Washer, Shim	AR	II	D	R
*	4-13-20	Spacer	2	II	C	T
*	4-13-21	Housing	2	III	C	T
*	4-13-22	Bearing	2	III	C	T
*	4-13-23	Retaining Ring	2	III	C	R
*	4-13-24	Shaft	2	III	C	T
	4-13-25	Support Bracket Fitting	2	III	D	R
	4-13-44	Screw	4	II	C	R
	4-13-45	Washer	4	I	D	R
	4-13-46	Nut	4	II	D	T

AR = As Required

TABLE IX. FMEA FOR UPPER ROLLER/BRACKET COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
4-13-20	Spacer	Broken/Bent	Excessive lateral forces due to sloppy roller restraint.	Increased lateral door movement during flight could overstress roller, leading to further loosening of restraint & possible roller failure.	Regular check of restraint torque will preclude such failure.	II, C, T
4-13-21	Housing	Broken	Roller overstressed due to improper adjustment.	Door becomes loose and misaligned. Could result in loss of door during flight.	Regular check of adjustment can prevent a critical failure.	III, C, T
		Worn	Improper adjustment and/or dirty track.	Rollers wear in spots or cease to rotate. Could lead to roller failure.	Frequent inspection will reveal wear before serious failure.	II, B, T
		Corroded	Exposure to elements and inadequate lubrication.	Causes roller wear and improper operation.	Regular inspection and lube can prevent corrosion.	II, C, T
4-13-22	Bearing	Loose	Light press fit with housing.	Introduces slop leading to increased lateral door movement during flight and possible roller failure.	-	III, C, T
		Worn	Improper adjustment or dirt accumulation.	Leads to increased lateral door movement during flight & possible roller failure.	-	III, C, T

TABLE IX. Continued

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
4-13-23	Retaining ring	Broken	Excessive lateral force due to sloppy roller restraint.	Increased lateral door movement during flight likely to cause roller failure.	-	III, C, R
4-13-24	Shaft	Bent	Overstressed by off-axis forces due to loose roller.	Door cannot be properly adjusted. Can cause excessive roller wear & roller failure.	Visual inspection can detect bent shaft before serious failure.	III, C, T

TABLE X. FMEA FOR UPPER ROLLER/BRACKET ASSEMBLIES

Mode of Failure		Failure Effect	Compensating Features	Criticality Code & Failure Class
Appearance or Behavior	Possible Cause			
Rollers become loose	Broken/bent parts, Loose parts, Worn parts.	Door loosening could lead to roller failure and possible loss of door in flight.	Loose door indicates need for maintenance before serious failure.	III, B, T
Roller out of alignment	Bent parts, Worn parts, Corroded parts.	Causes rollers to wear or bind in track.	Difficult or improper door operation indicates need for maintenance.	II, C, T
Roller broken	Broken parts.	Door not properly restrained, could lead to loss of door in flight.	-	III, C, T

Lower Roller Assembly

The detailed parts breakdown of the lower roller assembly is illustrated in Figure 31. Because of the predominant use of identical component parts in the forward and aft lower roller/bracket subassemblies, a combined detailed parts list was prepared covering both the subassemblies as shown in Table XI.

Table XII presents the results of the component level FMEA for the combined forward and aft roller/bracket subassemblies. The estimated percentages of expected lower roller assembly failures for each of the assumed failures listed in Table XII are:

Broken/Bent Parts	26%
Misaligned/Worn Parts	21%
Corroded/Unlubricated Parts ...	10%
Loose Parts	10%

The lower roller assembly level FMEA is presented in Table XII. The most probable functional failure modes for the lower roller assembly are predicted to be excessive roller wear, rollers out of adjustment, and broken rollers.

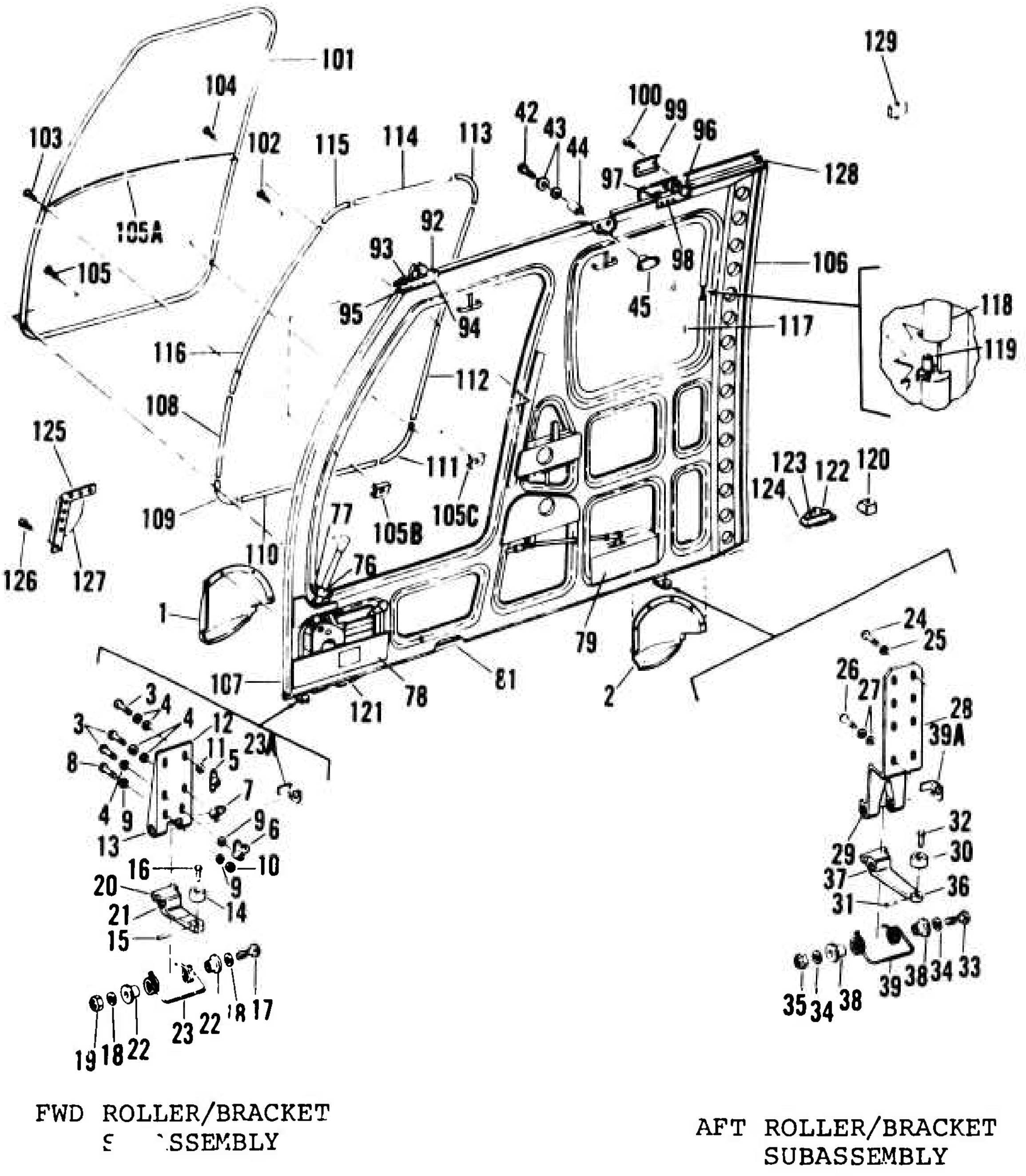


Figure 31. Parts Breakdown, Lower Roller Assembly.

TABLE XI. DETAILED PARTS LIST - PILOT RESCUE DOOR, LOWER FORWARD AND AFT ROLLER/BRACKET SUBASSEMBLIES

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	17-3, -24	Screw, Washer Head	10	I	C	R
	17-4, -25	Washer	13	I	D	R
	17-5,-6,-7	Nut, Plate	4	I	D	R
	17-8, -26	Screw, Washer Head	4	I	C	R
	17-9, -27	Washer	8	I	D	R
	17-10	Nut, Self-Locking, Plain	2	I	D	R
	17-11	Washer, Shim	AR	I	D	R
	17-12, -28	Bracket	2	II	D	R
	17-13, -29	Bushing	4	I	D	T
*	17-14, -30	Roller	2	III	C	T
	17-15, -31	Pin, Spring	2	II	C	R
*	17-16, -32	Pin, Flat Head	2	III	C	T
	17-17, -33	Bolt, Clevis	2	II	C	R
	17-18, -34	Washer	4	I	D	R
	17-19, -35	Nut	2	II	D	R
*	17-20, -36	Roller Arm	2	III	D	T
	17-21, -37	Bushing	2	I	D	T
	17-22, -38	Spool	4	I	D	T
*	17-23, -39	Spring	2	II	C	T
	17-23A,-39A	Shim	4	II	C	T

AS = As required

TABLE XII. FMEA FOR LOWER ROLLER/BRACKET COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
17-14,-30	Roller	Broken	Roller overstressed due to improper adjustment.	Failure of lower roller is likely to lead to loss of door in flight.	Regular check of adjustment might prevent a critical failure.	III, C, T
		Worn	Improper adjustment and/or dirty or bent track.	Rollers wear in spots or cease to rotate. Could lead to roller failure & subsequent loss of door.	Regular inspection can prevent a critical failure.	III, B, T
		Corroded	Exposure to elements and inadequate lubrication.	Door does not operate smoothly. Can lead to overstressing of roller arm or roller failure.	Inspection will reveal corrosion.	III, C, T
17-16,-32	Pin, flat head	Broken/bent	Overstressed due to improper adjustment.	Can lead to roller failure or roller disengagement & subsequent loss of door in flight.	-	III, C, T
17-20, -36	Roller arm	Broken/bent	Overstressed due to improper adjustment.	Likely to result in loss of door during flight.	Regular inspection may preclude serious failure.	III, D, T
17-23,-39	Spring	Loose	Weakened from flexing under load.	Roller may not be held properly in track. Could possibly lead to roller disengagement and subsequent loss of door during flight.	Down stops will hold roller arm in position.	II, C, T

TABLE XIII. FMEA FOR LOWER ROLLER/BRACKET ASSEMBLIES

Mode of Failure		Failure Effect	Compensating Features	Criticality Code & Failure Class
Appearance or Behavior	Possible Cause			
Excessive roller wear	Broken/bent parts, Misaligned parts, Corroded parts.	Loosening of door could lead to roller disengagement and subsequent loss of door in flight.	Regular inspection can prevent a critical failure.	III, B, T
Rollers out of adjustment	Bent parts, Loose parts.	Could lead to roller fatigue or disengagement and subsequent loss of door in flight.	Regular check of adjustment may preclude serious failure.	III, C, T
Rollers broken	Broken/bent parts.	Failure of roller is likely to lead to loss of door in flight.	Regular inspection can prevent a critical failure.	III, C, T

Door Jettison Subassembly

Figure 32 shows the detailed parts breakdown of the door jettison subassembly. The detailed parts list for this subassembly is given in Table XIV.

Table XV presents the results of the component level FMEA for those parts of the door jettison subassembly indicated in Table XIV as being critical to proper operation of that subassembly.

The estimated percentages for the most probable causes of operational failures of the door jettison subassembly based on the data of Table XV are:

Broken/Bent Parts 34%
Misaligned/Worn Parts 11%
Corroded/Unlubricated Parts ... 22%

The FMEA of Table XV indicates that the most probable causes of door jettison subassembly operational failures are broken cables and corroded pip pins.

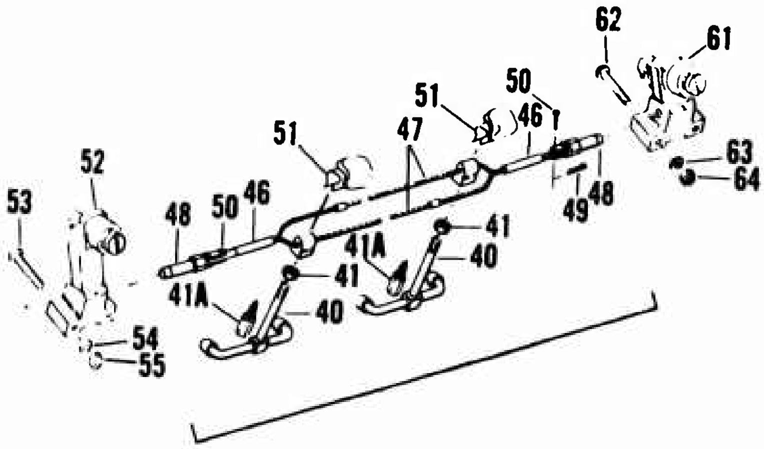


Figure 32. Parts Breakdown, Door Jettison Subassembly.

TABLE XIV. DETAILED PARTS LIST, - PILOT RESCUE DOOR, DOOR JETTISON SUBASSEMBLY

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	17-40	Handle Assembly	2	II	D	R
	17-41	Nut, Check	2	I	D	R
	17-41A	Fitting	2	II	C	R
*	17-46	Cable Fitting	2	II	C	R
*	17-47	Cable	2	II	B	R
*	17-48	Pin, Pip	2	III	B	R
	17-49	Pin, Cotter	2	II	C	R
	17-50	Pin, Flat Head	2	II	C	R
	17-51	Spring, Release	2	I	C	R

TABLE XV. FMEA FOR DOOR JETTISON COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
17-46	Cable fitting	Broken/bent	Experiences off-axis jettison load due to misalignment of mechanism.	Door will not jettison because pip pins are not removed.	Other doors may be used.	II, C, R
17-47	Cable	Broken	Misalignment or binding of mechanism under jettison load.	Door will not jettison because pip pins are not pulled.	Other doors may be used.	II, B, R
17-48	Pin, pip	Corroded	Exposure to elements and inadequate inspection.	Pins are frozen in fitting and jettison mechanism will not function.	Other doors may be used.	III, B, T
		Misaligned	Application of off-axis jettison load.	Door will not jettison because pip pins bind against fitting and do not pull out.	Other doors may be used.	III, C, R

Lanyard Subassembly

The detailed parts breakdown of the lanyard subassembly is illustrated in Figure 33, while Table XII shows the detailed parts list and indicates those parts critical to proper subassembly operation.

The results of the component level FMEA for the critical parts of the lanyard subassembly are presented in Table XVII. Based on these results, the estimated percentages of lanyard failures attributable to each of the assumed failures tabulated are:

Broken/Bent Parts	40%
Misaligned/Worn Parts ...	13%
Loose Parts	13%

From the FMEA of Table XVII, the most probable causes of operational lanyard subassembly failures are predicted to be broken lanyards and bent fittings due to improper installation and rough handling.

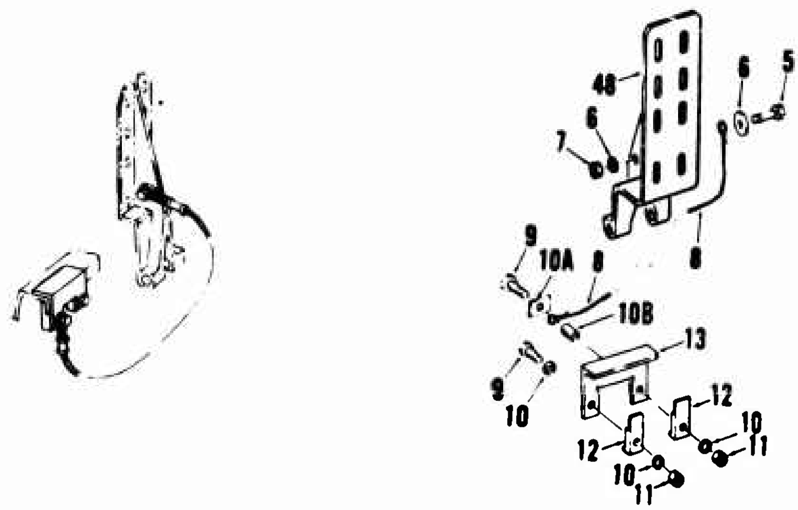


Figure 33. Parts Breakdown, Lanyard Subassembly.

TABLE XVI. DETAILED PARTS LIST, - PILOT RESCUE DOOR, LANYARD SUBASSEMBLY

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	4-13-5	Bolt	1	II	C	R
	4-13-6	Washer	2	I	D	R
	4-13-7	Nut	1	II	D	R
*	4-13-8	Lanyard	1	II	C	R
	4-13-9	Bolt	2	II	C	R
	4-13-10	Washer	2	I	D	R
	4-13-11	Nut	2	II	D	R
	4-13-10A	Washer	1	I	D	R
	4-13-10B	Spacer	1	I	C	R
*	4-13-12	Fitting	2	II	C	T
*	4-13-13	Fitting, Arrester	1	II	C	T

TABLE XVII. FMEA FOR LANYARD SUBASSEMBLY COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
4-13-8	Lanyard	Broken	Mishandling, improper installation.	Safety feature of lanyard is lost.	-	II, C, R
4-13-12	Fitting	Broken/bent	Rough door movement, improper installation.	Arrester fitting may disengage from track, causing loss of safety feature.	-	II, C, T
		Loose	Rough door movement, binding on bent track.	May cause disengagement from track and loss of safety feature.	Regular inspection may reveal loose fitting before failure.	II, C, T
4-13-13	Fitting, arrester	Broken/bent	Misalignment and/or binding on track.	May disengage from track, causing loss of safety feature.	Regular inspection may preclude serious failure.	II, C, T
		Worn	Improper installation, misaligned track.	May become loose and eventually disengage from track.	Regular inspection may preclude serious failure.	II, C, T

Box Step Assembly

The box steps are built into the side of the fuselage to provide access to the roof of the helicopter. Cutouts in the aircraft skin of sufficient size to accommodate protective footwear are bounded at the bottom edges by channel-shaped members bridging between adjacent frames. These channel members provide the step capability. The cutouts are closed off inboard by the insertion of light-gage metal shells. A hinged door flush with the outer skin encloses the box step.

The major parts of the box step and their identification numbers as given in Reference 27* are listed in Table XVIII. The step installation also includes numerous minor parts consisting of doublers, fillers, angles, clips and rivets. Of the major parts, only the step and the box are considered to be critical components for proper performance of the box step function. An FMEA has been performed for these parts, and the results are presented in Table XIX.

The estimated percentages of the most probable causes of box step failures are:

Broken/Bent Parts	22%
Misaligned/Worn Parts	15%
Corroded/Unlubricated Parts ...	30%

On the basis of the Table XIX FMEA, the most likely failure mode for the box step assembly is predicted to be corrosion of the step member.

*Reference 27: Kaman Drawing K631729, Step Installation.

TABLE XVIII. DETAILED PARTS LIST - FUSELAGE BOX STEP

Critical Component	Part Ident	Part Description	No. Of Each	Crit Code	Fail Prob	Fail Class
	K631729-11	Door	1	I	C	T
*	-13	Step	1	II	B	T
*	-17	Box	1	II	B	T
	-23	Hinge Half	1	I	C	T
	-25	Hinge Half	1	I	C	T
	-27	Pin	1	I	C	T

TABLE XIX. FMEA FOR BOX STEP COMPONENTS

Diag. Item No.	Part Name	Assumed Failure	Possible Cause	Failure Effect	Compensating Features	Criticality Code & Failure Class
-13	Step	Broken/bent	Heavy loads applied during constant use.	Failure of step can lead to primary skin damage at bottom edge of cutout.	-	II, C, T
		Worn	Erosion of protective finish from constant use.	Removal of protective finish leaves step susceptible to corrosion.	-	I, B, [illegible]
		Corroded	Exposure of step to elements & corrosive agents on shoes.	Can lead to weakening of step structure and breaking/bending of step.	-	I, B, T
-17	Box	Broken/bent	Foot loads applied to box through constant use.	Failure of box may permit corrosive agents to enter fuselage structure.	-	II, B, T
		Corroded	Exposure of box to elements and corrosive agents on shoes.	May permit corrosive agents to enter fuselage structure.	-	II, B, T

COMPARISON OF PREDICTED FAILURES WITH DOCUMENTED FIELD DATA

Reference 26* presents summary data of H-2 field service experience which includes tabulations of actual percentages of failure causes recorded for most of the secondary structure assemblies and subassemblies investigated during the reliability analysis. The safety lanyard is the only subassembly that has been evaluated for which no failure data is given in Reference 26.

The field data for the handle/lock assembly, door roller assembly, door jettison subassembly, and box step assembly provide a basis for comparing causes of failure predicted by the FMEA with actual failure causes experienced under operational conditions and for evaluating the effectiveness of the FMEA method in highlighting failure areas where the application of new or modified design and testing criteria will improve reliability and maintainability.

To allow direct comparison of the predicted and actual failure causes, the failure categories used in Reference 26 were rearranged somewhat to conform more closely to the categories used in the current reliability analysis. For example, the two field data categories of worn and improper adjustment were combined and are reported here under the misaligned/worn category. The broken and cracked failure categories of Reference 26 are reported here under the broken/bent category, while the corroded and lack of lube categories listed separately in the field data summary are combined here and reported under the corroded/unlubricated category. The Reference 26 data also includes a missing-hardware failure category. Failures attributable to missing hardware are not readily predictable and were not considered in the reliability analysis. For this reason, field data reported under the missing-hardware category were not used in comparing the predicted and actual failure causes.

The handle/lock assembly failure data presented in Table XX show that the FMEA overestimated the percentages of failures in the broken/bent and misaligned/worn categories, while predicting quite closely the failure percentages in the corroded/unlubricated and loose categories. The overall correlation between the two sets of data, however, is judged to be as good as can be expected using this type of predictive analysis. A comparison of the predicted and actual failure data for the door roller assembly (including predicted upper and lower roller data summed and averaged) is shown in Table XXI. Here the

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*Reference 26: Kaman Report R-983, H-2 ARP Program.

FMEA slightly overestimated the percentage of failures in the broken/bent category and slightly underestimated the percentage in the misaligned/worn category. Data in the corroded/unlubricated category compare quite closely; however, no field data are reported in the loose category. Overall correlation between the two sets of data is considered to be quite good.

For the door jettison subassembly data given in Table XXII, the overall correlation is not as good as noted previously for the handle/lock and door roller assemblies. The FMEA significantly underestimated the percentage of failures in the broken/bent category, while strongly overestimating the percentage of failures in the misaligned/worn category and the corroded/unlubricated category. A possible explanation for this discrepancy between the predicted and actual data is that initial failures in the corroded/unlubricated and misaligned/worn categories, not detected as such during routine maintenance or inspection, might eventually result in a broken/bent failure at some later time when jettison of the door is attempted. If this is indeed the case, then some portion of the predicted corroded/unlubricated and misaligned/worn failures would be expected to appear as broken/bent failures in field data reports. Sequential failures of this type are quite possible in the jettison subassembly, since it is an emergency mechanism which is not normally used or tested in day-to-day operations. Because of this, failures in the misaligned/worn and corroded/unlubricated categories are not easily detected.

The results of the comparison of predicted and actual failure data for the box step assembly, presented in Table XIII, show discrepancies similar to those noted for the jettison subassembly. In this case the predicted percentage of failures in the misaligned/worn category is substantially larger than the actual percentage of failures reported in Reference 26, while the predicted percentage in the broken/bent category is significantly smaller than the reported field data percentage. Here again it seems possible that failures in the misaligned/worn category, which go undetected in the field, can result eventually in broken/bent failures if strict maintenance and inspection procedures are not followed.

In summary, the comparison of predicted failures with documented field data shows reasonably good correlation for actively functioning mechanisms such as the handle/lock assembly and door roller assembly, whose normal day-to-day use provides an almost continual opportunity for evaluating the performance of the assembly and for detecting failures, even inadvertently at times. On the other hand, for seldom used or passive mechanisms such as the door jettison subassembly and the box step assembly, the correlation of predicted and actual failures is

fair at best, perhaps due to a lack of strict compliance to maintenance and inspection procedures leading to more serious failure modes in actual field experience.

TABLE XX. HANDLE/LOCK ASSEMBLY FAILURE DATA COMPARISON

Failure Cause	Percentage of Total Failures	
	Analytical Prediction	Field Data
Broken/Bent	33	24
Misaligned/Worn	23	19
Corroded/Unlubricated	8	8
Loose	3	4

TABLE XXI. ROLLER ASSEMBLY (UPPER & LOWER)
FAILURE DATA COMPARISON

Failure Cause	Percentage of Total Failures	
	Analytical Prediction	Field Data
Broken/Bent	28	23
Misaligned/Worn	22	25
Corroded/Unlubricated	9	10
Loose	9	-

TABLE XXII. DOOR JETTISON SUBASSEMBLY DATA COMPARISON

Failure Cause	Percentage of Total Failures	
	Analytical Prediction	Field Data
Broken/Bent	34	50
Misaligned/Worn	11	6
Corroded/Unlubricated	22	8

TABLE XXIII. BOX STEP ASSEMBLY DATA COMPARISON

FAILURE CAUSE	Percentage of Total Failures	
	Analytical Prediction	Field Data
Broken/Bent	22	33
Misaligned/Worn	15	2
Corroded/Unlubricated	30	34

RELIABILITY ANALYSIS CONCLUSIONS

Correlation between causes of failure in secondary structures predicted by failure mode and effects analyses and causes actually experienced in service, including the relative frequencies of occurrence of these failures, is reasonably good considering the lack of any historical component data upon which to base the predictions. The analysis shows that the FMEA technique can be used effectively in the evaluation of new designs for predicting primary failure causes and highlighting weaknesses in the design where further refinement and functional testing can provide an improvement in reliability.

A general requirement for FMEA's in a secondary structure specification would be useful as part of an overall reliability review of a new design concept. However, requiring the prediction of quantitative values of failure rates and MTBF's would involve a significant analytical effort which may not be justified, in many cases, due to the limited data bank of statistical mechanical component failure data and the questionable validity of these data. Thus it is concluded that the insight gained through the FMEA can be valuable, but failure rate prediction may provide only a small additional payoff in design improvement for a relatively large increase in level of effort.

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1.	MIL-A-8860	Airplane Strength and Rigidity - General Specification
2.	MIL-A-008861A	Airplane Strength and Rigidity - Flight Loads
3.	MIL-A-8862	Airplane Strength and Rigidity - Landplane Landing and Growth Handling Loads
4.	MIL-A-8863	Airplane Strength and Rigidity - Additional Loads for Carrier-Based Landplanes
5.	MIL-A-8864	Airplane Strength and Rigidity - Water and Handling Loads for Seaplanes
6.	MIL-A-008865A	Airplane Strength and Rigidity - Miscellaneous Loads
7.	MIL-A-8866	Airplane Strength and Rigidity - Reliability Requirements - Repeated Loads and Fatigue
8.	MIL-A-008867A	Airplane Strength and Rigidity - Ground Tests
9.	MIL-A-8868	Airplane Strength and Rigidity - Data and Reports
10.	MIL-A-8869	Airplane Strength and Rigidity - Nuclear Weapons Effects
11.	MIL-A-8870	Airplane Strength and Rigidity - Vibration, Flutter and Divergence
12.	MIL-A-8871	Airplane Strength and Rigidity - Flight and Ground Operations Tests
13.	MIL-S-8698	Structural Design Requirements - Helicopters
14.	MIL-T-8679	Test Requirements, Ground, Helicopters
15.	AR-56	Structural Design Requirements, Helicopters

16.	SD-24J	General Specification for Design and
17.	SD-24K Vols. I & II	Construction of Aircraft Weapons Systems

Other Documents:

Air Force Systems Command Design Handbook

Series 1-0

18.	Vol. DH 1-1	General Index and Reference
19.	Vol. DH 1-2	General Design Factors
20.	Vol. DH 1-9	Maintainability
21.	Vol. DH 1-X	Checklist of General Design Criteria

Series 2-0

22.	Vol. DH 2-1	Airframe
23.	Vol. DH 2-2	Crew Stations and Passenger Accommodations

Federal Airworthiness Regulations

24.	Part 27	Airworthiness Standards - Normal Category Rotorcraft
25.	Part 29	Airworthiness Standards - Transport Category Rotorcraft

Reports

26. Cook, T. N., and Zubkoff, H., H-2 HELICOPTER ANALYTICAL REWORK PROGRAM DATA SURVEY TASK (3-M AND INSPECTION REVIEW), Kaman Aerospace Corporation; NADC Report No. R-983, Naval Air Development Center, Warminster, Pennsylvania, January 1972.

Drawings

27. Kaman Drawing K631729, Step Installation

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-1	Nose Door Structure	Nose Doors Interior	Airframe	2	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Horizontal and vertical channels and supports, shelves and frame members become dented, bent and buckled due to frequent removal and installation of equipment in the nose doors.

CONTRIBUTING FACTORS: Compact arrangement of equipment in nose doors is conducive to structural damage. Some structural members are too light and inadequately protected from handling damage. Adequate bumpers and guides for equipment are lacking.

USUAL CORRECTIVE ACTION: Repair in accordance with Structural Repair Manual.

PAR

WUC AREA:	PAR INTVL:	% OF PARS	AVG/PAR
11100/ 1A	EA.	44	3.0

PRIMARY FAILURE MODES:
1. Bent, Dented, Buckled
2.
3.

DISPOSITION (PERCENT):

REPAIR	REPLACE	TREAT	SCRAP
88	6	6	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
11111	Nose Door Assembly	Cal.	☐ SPECIFIC ☒ GENERAL	MTBF 363 MTBR 20693	MTTR 0.5 MH/MA 0.5	ORG. .001 INT. -	MH/FH: 0.2 NORM: - FAILURES: 0.8 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	
WEATHER/ENVIRONMENT	64.9
COMMON HARDWARE	1.8
ALL OTHER	33.3

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	
IN-FLT (No Abort)	5.3
PRE-FLT/POST-FLT/DAILY INSP.	12.3
CALENDAR INSP.	35.1
OTHER	47.3

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	58.1
2. Cracked	9.7
3. Loose	9.7
4. Worn / Chafed	6.5
5. Punctured	6.5
TOTAL FIVE-HIGH	90.3

APPLICABLE PART NUMBERS:

NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☐ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS. Recommend incorporation of rubber/phenolic bumpers and guides and relocation of some nose door equipment. Heavier gage shelves and supports should be provided. Polyurethane finish also recommended to improve corrosion resistance.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-3

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-2	Hinge, Nose Door	Forward Fuselage	Airframe	4	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Lower nose door hinges crack and break at hinge lugs. Corrosion develops between hinge bolts and lugs.

CONTRIBUTING FACTORS: Hinges are aluminum and attaching bolts are steel. The corrosion which develops between the hinge bolts and lugs causes the hinges to bind and become overstressed when doors are opened. Weight of equipment installed in nose doors contributes to problem.

USUAL CORRECTIVE ACTION: Bolts removed to permit cleaning and treating of corrosion when discovered. Broken and damaged hinges replaced per MMI.

PAR

WUC AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11100/1A 11100/1B 11200/3A 11200/3B	EA.	% OF PARS 48 AVG/PAR 2.8	1. Cracked 2. Corroded 3.	REPAIR 35 REPLACE 47 TREAT 18 SCRAP 0	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
11112	Nose Door Hinge	Daily	☒ SPECIFIC ☐ GENERAL	MTBF 216 MTBR 2956	MTTR: 0.8 MH/MA 1.1	ORG. .005 INT. -	MH/FH: 0.7 NORM: 0.8 FAILURES: 1.4 NORS: 2.3

FAILURES BY CAUSE:	%
MAINT. OPER. ERROR	5.2
WEATHER ENVIRONMENT	64.6
COMMON HARDWARE	7.3
ALL OTHER	22.9

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	1.0
IN-FLT (No Abort)	2.1
PRE-FLT/POST-FLT/DAILY INSP.	21.9
CALENDAR INSP.	22.9
OTHER	52.0

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	64.6
2. Broken	10.4
3. Cracked	8.3
4. Improper Maint.	3.1
5. Missing Hardware	3.1
TOTAL FIVE-HIGH	89.6

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K633066-11	6730
K633066-12	2404
K633067-11	8412
K633067-12	16825
AN24-38	8412

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: NARF Q.P. LES #9 changes aluminum alloy hinge to 4130 cad. plated steel. Recommend a redesigned stainless steel hinge with larger lugs. Also recommend larger hollow hinge bolt with integral lube fitting and associated passages to permit lube flow to each lug.

PRIOR HISTORY:
- ☐ D & I
- ☒ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No.R-983 Page 2-4

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-3	Latch, Nose Door	Nose Doors (two places)	Airframe	2	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Bending, cracking and corrosion of latch handle and locking pin.

CONTRIBUTING FACTORS: Improper alignment of nose doors when closing the doors causes excessive loads on the latch. Area is exposed to corrosive elements.

USUAL CORRECTIVE ACTION: Latch replacement per MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11100/1A 11100/1B	EA.	% OF PARS 60 AVG/PAR 1.7	1. Bent 2. Corroded 3. Cracked	35 REPAIR, 42 REPLACE, 23 TREAT, 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM
11113	Nose Door Latch Mechanism	Daily	☒ SPECIFIC ☐ GENERAL	MTBF 195 MTBR 6898	MTTR: 0.6 MH/MA 0.6	ORG. .003 INT. -	MH/FH: 0.4 FAILURES: 1.6 NORM: - NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	0.9
WEATHER/ENVIRONMENT	81.1
COMMON HARDWARE	0.9
ALL OTHER	17.0

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	0.9
IN-FLT (No Abort)	4.7
PRE-FLT/POST-FLT/DAILY INSP.	11.3
CALENDAR INSP.	13.2
OTHER	69.8

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	81.1
2. Broken	4.7
3. Cracked	3.8
4. Adjust./Align.	3.8
5. Loose	1.9
TOTAL FIVE-HIGH	95.1

APPLICABLE PART NUMBERS: NUMBER	MTBR
H9125D	1463

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Improve provisions for correct alignment when closing doors. Increase latch handle material gage. Change lock pins, latch hook and handle pins to an improved corrosion resistant material.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-4	Seals, Nose Door	Foreward Fuselage	Airframe	10	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Flat rubber seals and P-seals become deteriorated, torn and unbonded. Loose seals permit water entry, contributing to corrosion in forward fuselage compartments.

CONTRIBUTING FACTORS: Rubber seal material deteriorates prematurely. Bonding is adversely affected by the elements causing loss of seal sections. Seals are in several sections causing gaps as a function of shrinkage and loss.

USUAL CORRECTIVE ACTION: Replace per the MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11100/IA 11100/IB		% OF PARS 76 AVG/PAR 38	1. Torn 2. Deteriorated 3. Unbonded, Loose	43 REPAIR · 57 REPLACE · 0 TREAT · 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.			MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		Daily	☐ SPECIFIC ☐ GENERAL	MTBF ___ MTBR ___	MTTR: ___ MH/MA ___	ORG. ___ INT. ___	MH/FH: ___ NORM: ___ FAILURES: ___ NORS: ___

FAILURES BY CAUSE: %
- MAINT./OPER. ERROR
- WEATHER/ENVIRONMENT
- COMMON HARDWARE
- ALL OTHER

FAILURES BY WHEN DISC. %
- PRE-FLT/IN-FLT (Abort)
- IN-FLT (No Abort)
- PRE-FLT/POST-FLT/DAILY INSP.
- CALENDAR INSP.
- OTHER

FIVE-HIGH FAILURE CAUSES: %
1.
2.
3.
4.
5.

TOTAL FIVE-HIGH —

APPLICABLE PART NUMBERS.

NUMBER	MTBR
K633065-411	11216
K633065-413	11216
K633065-619	11216
K633065-635	11216

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Redesign to a one piece seal on each door. Change to a rubber impregnated fabric - or a material less susceptible to deterioration. Add mechanical fasteners supplemented by bonding - in lieu of bonding only.

PRIOR HISTORY.
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No. R-983 Page 2-7

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-6	Pin-Rear Mount-Avionic Equipment	Forward Fuselage Tub Section	Airframe	6	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: The spring mounted pins which retain the aft end of avionic equip. in the tub area are frequently found broken and missing primarily as a result of handling damage.

CONTRIBUTING FACTORS: Lack of tracks & guides for avionic equip. often causes equip. to improperly engage the mount pins upon installation. Damage results when heavy equip. is slammed into the pins. Channels supporting the pins are too light.

USUAL CORRECTIVE ACTION: Repair and replacement per the Structural Repair Manual and MMI. Repair is very time-consuming because of poor accessibility to the pin attaching hardware.

PAR

WUC AREA:	PAR INTVL:	% OF PARS / AVG PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11200/3A 11200/3B	EA.	% OF PARS 12 AVG PAR 2.7	1. Broken, Missing 2. Corroded 3.	25 REPAIR, 50 REPLACE, 25 TREAT, SCRAP	☐ WITHIN T.O. ☒ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR: / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		Cal.	☐ SPECIFIC ☐ GENERAL	MTBF __ MTBR __	MTTR: __ MH/MA __	ORG. __ INT. __	MH/FH: __ NORM: __ FAILURES: __ NORS: __

FAILURES BY CAUSE:	%	FAILURES BY WHEN DISC.	%	FIVE-HIGH FAILURE CAUSES:	%
MAINT./OPER. ERROR		PRE-FLT/IN-FLT (Abort)		1.	
WEATHER ENVIRONMENT		IN-FLT (No Abort)		2.	
COMMON HARDWARE		PRE-FLT/POST-FLT/DAILY INSP.		3.	
ALL OTHER		CALENDAR INSP.		4.	
		OTHER		5.	
				TOTAL FIVE-HIGH	—

APPLICABLE PART NUMBERS:

NUMBER	MTBR
NAS 574	5608

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to __
- Increase to __

PAR INSP. INTERVAL.
- No Change X
- Reduce to __
- Increase to __

REMARKS/RECOMMENDATIONS: Increase gage of channels to which pins are bolted. Provide new pin assembly or new bracket which provides better access to the attaching hardware. (Addition of avionic equip. tracks and guides is covered under Item 11-5)

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No. R-983 Page 2-8

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-7	Sliding Door Seals	Cockpit and Cabin Sliding Doors	Airframe	7	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Seals deteriorate, tear and loosen through handling damage and exposure to the elements. Defective seals permit water entry and reduce effectiveness of cabin heat system.

CONTRIBUTING FACTORS: Seal material susceptible to deterioration and tearing. Location of seals makes them vulnerable to damage when people and cargo enter and leave the cabin areas.

USUAL CORRECTIVE ACTION: Replaced per the MMI. Method of attachment makes replacement very time-consuming.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11310/6B 11320/6A 11330/6B	EA.	% OF PARS 96 AVG/PAR 10.5	1. Torn, Split, Cut 2. Unbonded, Loose 3. Deteriorated	17 REPAIR 83 REPLACE 0 TREAT 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR: / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		Cal.	☐ SPECIFIC ☐ GENERAL	MTBF — MTBR —	MTTR: — MH/MA —	ORG. — INT. —	MH/FH: ____ NORM: ____ FAILURES: ____ NORS: ____

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	
WEATHER/ENVIRONMENT	
COMMON HARDWARE	
ALL OTHER	

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	
IN-FLT (No Abort)	
PRE-FLT/POST-FLT/DAILY INSP.	
CALENDAR INSP.	
OTHER	

FIVE-HIGH FAILURE CAUSES:	%
1.	
2.	
3.	
4.	
5.	
TOTAL FIVE-HIGH	—

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K633010-271	11216
K633010-299	-
K633015-279	-
K633015-261	-
K633015-253	-
K633020-225	-
K633020-185	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Design change to incorporate improved seal material less susceptible to deterioration and tearing. Seal retention should employ use of screws - vice rivets & bonding - to reduce replacement man-hours.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-8	Rain Shields, Sliding Doors	Forward and Center Fuselage	Airframe	3	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Rain shields become torn, cracked & broken as a result of exposure to the weather & aircraft wind-stream & thru personnel handling damage. (Shields were formerly fiberglass and are now made of rubber)

CONTRIBUTING FACTORS: Rubber does not withstand effects of the elements and personnel handling.

USUAL CORRECTIVE ACTION: Replaced per Structural Repair Manual.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11200/6A 11200/6B 11400/6B	EA.	% OF PARS 48 AVG/PAR 1.5	1. Cracked, Broken 2. Torn, Split, Cut 3.	56 REPAIR 44 REPLACE 0 TREAT 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.			MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		*	☐ SPECIFIC ☐ GENERAL	MTBF __ MTBR __	MTTR: __ MH/MA __	ORG. __ INT. __	MH/FH: __ NORM: __ FAILURES: __ NORS: __

FAILURES BY CAUSE: %	FAILURES BY WHEN DISC. %	FIVE-HIGH FAILURE CAUSES: %	APPLICABLE PART NUMBERS:
MAINT./OPER. ERROR WEATHER/ENVIRONMENT COMMON HARDWARE ALL OTHER	PRE-FLT/IN-FLT (Abort) IN-FLT (No Abort) PRE-FLT/POST-FLT/DAILY INSP. CALENDAR INSP. OTHER	1. 2. 3. 4. 5. TOTAL FIVE-HIGH —	NUMBER MTBR Locally manufactured item.

RECOMMENDATIONS

IMPROVEMENT CATAGORY	FLEET INSP. INTERVAL.	REMARKS/RECOMMENDATIONS:	PRIOR HISTORY:
☐ FLIGHT SAFETY ☒ USEFUL LIFE ☒ PAR COST ☒ OPERATING COST	No Change X Reduce to __ Increase to ea. Cal. PAR INSP. INTERVAL. No Change X Reduce to __ Increase to __	Change shield material to aluminum alloy. *Add to Calendar Inspection MRC: (not presently called out specifically)	☐ D & I ☐ U. R. ☐ S. I. R. ☐ Field Rep. Reports ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-10

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-9	Door Handle/Linkage	Cabin Sliding Doors	Airframe	3	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Handle and linkage become corroded and worn. Linkage binds causing parts to be overstressed.

CONTRIBUTING FACTORS: Lack of inspection and lube requirements.

USUAL CORRECTIVE ACTION: Clean and lube to correct binding. Replace worn and defective parts per the MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11310/6B 11320/6A 11330/6B	EA.	% OF PARS 96 AVG/PAR 10.9	1. Worn 2. Corroded 3.	REPAIR 81 REPLACE 0 TREAT 19 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
11313 11325 11333	Handle and Lock	Daily	☐ SPECIFIC ☒ GENERAL	MTBF 98 MTBR 20693	MTTR 1.0 MH/MA 1.3	ORG. .014 INT. -	MH/FH: 1.9 NORM: 1.0 FAILURES: 3.1 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	3.8
WEATHER/ENVIRONMENT	11.7
COMMON HARDWARE	13.7
ALL OTHER	70.7

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	0.9
IN-FLT (No Abort)	35.5
PRE-FLT/POST-FLT/DAILY INSP.	36.6
CALENDAR INSP.	8.1
OTHER	18.9

FIVE-HIGH FAILURE CAUSES:	%
1. Broken	24.2
2. Alignment/Adjust.	19.0
3. Missing Hdw.	9.0
4. Corroded	7.5
5. Loose	3.8
TOTAL FIVE-HIGH	63.5

APPLICABLE PART NUMBERS:

NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change ____
- Reduce to ____
- Increase to ea. Cal.

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Add handle and linkage to Calendar Inspection requirements and lube list. (These items have already been included in corrosion control MRC deck which should alleviate corrosion problem.)

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No. R-983 Page 2-11

STATEMENT OF PROBLEM

ITEM NO.	ITEM	LOCATION	SYSTEM	QPA	SOURCE
11-10	Roller Assembly, Sliding Door	Cargo Door, Pilot/Rescue Door, Copilot's Door	Airframe	12	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Door rollers become corroded, worn, cracked & broken causing doors to loosen & create excessive track wear. (See Item 11-11). Door separation is a flight safety concern.

CONTRIBUTING FACTORS: Roller design and exposed locations, together with improper rigging procedures, are conducive to wear, corrosion and roller failures.

USUAL CORRECTIVE ACTION: Replaced per the MMI.

PAR

WUC/AREA: 11310/6B, 11320/6A, 11330/6B

PAR INTVL: EA.

% OF PARS 96
AVG/PAR 13.3

PRIMARY FAILURE MODES:
1. Worn
2. Corroded
3. Cracked, Broken

DISPOSITION (PERCENT):

REPAIR	REPLACE	TREAT	SCRAP
91	0	9	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC: 11312, 11332, 11316, 11336, 11322, 11326

NOMENCLATURE: Rollers/Brackets, Upper and Lower

INSP. INTVL. Daily Cal.

DATA APPL.: ☐ SPECIFIC ☒ GENERAL

MTBF 74.6 **MTBR** 769

MTTR 0.9 **MH/MA** 1.2

MH/FH: ORG. .017 INT. -

WUC PERCENT OF SYSTEM: MH/FH: 3.0 WORK: 4.5 FAILURES: 4.1 NORS: 0.1

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	3.6
WEATHER/ENVIRONMENT	19.9
COMMON HARDWARE	4.4
ALL OTHER	72.1

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	0.4
IN-FLT (No Abort)	24.4
PRE-FLT/POST-FLT/DAILY INSP.	38.2
CALENDAR INSP.	19.2
OTHER	17.9

FIVE-HIGH FAILURE CAUSES:	%
1. Broken	22.7
2. Adjust. Improper	19.5
3. Lack of Lube	9.8
4. Missing Hdw.	6.5
5. Worn	5.8
TOTAL FIVE-HIGH	64.3

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K633087-13	33649
K633087-17	-
K633079- 9	16825
K633080- 7	4206

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☒ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
No Change X
Reduce to ____
Increase to ____

PAR INSP INTERVAL.
No Change X
Reduce to ____
Increase to ____

REMARKS/RECOMMENDATIONS:
1. Compliance with IAB 182 Inspection and Rigging Procedure.
2. Submittal & approval of ECP 337
3. Corrosion inspection & prevention procedure per Corrosion MRC's.

PRIOR HISTORY:
- ☐ D & I
- ☒ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-12

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-11	Door Tracks	Cargo Door, Pilot/Rescue Door, Copilot's Door	Airframe	6 Assy's	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Upper & lower sliding door tracks become worn, gouged, cracked & broken. Failure of the tracks is associated with door roller problems (Item 11-10)

CONTRIBUTING FACTORS: Failure to adhere to MMI door rigging instructicns has resulted in excessive vertical play and track failures.

USUAL CORRECTIVE ACTION: Track sections replaced per Structural Repair Manual.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11200/6A 11200/6B 11400/6B	EA.	% OF PARS 88 AVG/PAR 4.8	1. Worn 2. Gouged, Nicked, Dented 3. Cracked, Broken	85 REPAIR 8 REPLACE 7 TREAT 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
1121B 1121K 11417	Door Sills/Tracks	Daily Cal.	☐ SPECIFIC ☒ GENERAL	MTBF 88.5 MTBR 20693	MTTR: 1.2 MH/MA 1.5	ORG. .006 INT. -	MH/FH: 3.1 NORM: 1.3 FAILURES 0.2 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	3.4
WEATHER/ENVIRONMENT	68.3
COMMON HARDWARE	8.4
ALL OTHER	20.1

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	0.7
IN-FLT (No Abort)	5.5
PRE-FLT/POST-FLT/DAILY INSP.	9.1
CALENDAR INSP.	30.7
OTHER	54.0

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	65.2
2. Broken	5.4
3. Missing Hardware	4.6
4. Worn	4.1
5. Lack of Lube	1.2
TOTAL FIVE-HIGH	80.5

APPLICABLE PART NUMBERS:	
NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☒ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS:

1. IAB 182 specifically defines inspection & correct rigging. Compliance will reduce track defects.
2. ECP 337, currently in process, will provide improved rollers & brackets, which will reduce track wear and track failures. (Item 11-10).
3. Strict compliance with corrosion MRC Deck is required.

PRIOR HISTORY:
- ☐ D & I
- ☒ U. R.
- ☒ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-13

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-12	Door Jettison Mechanism	Cabin Sliding Doors	Airframe	3	☐ CFE ☐ GFE

NATURE OF DISCREPANCY:	CONTRIBUTING FACTORS:	USUAL CORRECTIVE ACTION:
Jettison mechanism becomes frozen and inoperative. System is checked at Calendar Inspection.	Corrosion of jettison system pip-pins prevents withdrawal of pins, resulting in an inoperative jettison system.	Disassembly, cleaning and lubrication per the MMI. Very time-consuming procedure.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11310/6B 11320/6A 11330/6B	EA.	% OF PARS 5.2 AVG/PAR 1.3	1. Inoperative, Frozen 2. 3.	88 REPAIR, 0 REPLACE, 12 TREAT, 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
11314 11324 11334	Door Jettison Mechanism	Cal.	☒ SPECIFIC ☐ GENERAL	MTBF 345 MTBR -	MTTR: 0.7 MH/MA 0.7	ORG. .002 INT. -	MH/FH: 0.3 NORM: - FAILURES: 0.7 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	1.6
WEATHER/ENVIRONMENT	3.1
COMMON HARDWARE	42.[illegible]
ALL OTHER	52.9

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	28.3
PRE-FLT/POST-FLT/DAILY INSP.	45.1
CALENDAR INSP.	6.5
OTHER	20.1

FIVE-HIGH FAILURE CAUSES:	%
1. Broken	25.6
2. Broken Wire	24.3
3. Missing Hdw.	10.0
4. Corroded	7.7
5. Improp. Positioned	5.7
TOTAL FIVE-HIGH	73.3

APPLICABLE PART NUMBERS: NUMBER	MTBR
K633030-7	-
5145-4-09	3365

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☒ FLIGHT SAFETY
- ☐ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change ______
- Reduce to ______
- Increase to X

PAR INSP. INTERVAL.
- No Change X
- Reduce to ______
- Increase to ______

REMARKS/RECOMMENDATIONS:

1. Increase Lube requirement per Calendar MRC #19 to a Special 30-day requirement.

2. Delete existing jettison system and incorporate "Kick-out" windows in sliding doors.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-14

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-13	Roof Window	Cockpit	Airframe	2	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Broken, Cracked.

CONTRIBUTING FACTORS: Window flexing has occurred during high speeds - nose down attitude - resulting in cracked and broken cockpit roof windows.

USUAL CORRECTIVE ACTION: Replace per MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS	AVG/PAR	PRIMARY FAILURE MODE:
11400/6E	EA.	48	1.0	1. Cracked, Damaged 2. 3.

DISPOSITION (PERCENT): 25 REPAIR; 75 REPLACE; 0 TREAT; 0 SCRAP

DISP IS USUALLY: ☐ WITHIN PAR ☒ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.
11213	Roof Window	Daily Cal.	☒ SPECIFIC ☐ GENERAL

MTBF 252; MTBR 1478; MTTR: 2.2; MH/MA 3.4

MH/FH: ORG. .013; INT. -

WUC PERCENT OF SYSTEM: MH/FH: 1.9; NORM: 1.0; FAILURES: 1.2; NORS: 1.5

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	15.9
COMMON HARDWARE	6.1
ALL OTHER	78.0

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	1.2
IN-FLT (No Abort)	19.5
PRE-FLT/POST-FLT/DAILY INSP.	42.7
CALENDAR INSP.	13.4
OTHER	23.2

FIVE-HIGH FAILURE CAUSES:	%
1. Broken	30.5
2. Cracked	26.8
3. Corroded	15.9
4. Leaking	4.9
5. Worn	2.4
TOTAL FIVE-HIGH	80.5

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K633034-205	1402
K633034-207	11216

RECOMMENDATIONS

IMPROVEMENT CATAGORY: ☒ FLIGHT SAFETY ☒ USEFUL LIFE ☐ PAR COST ☒ OPERATING COST

FLEET INSP. INTERVAL.: No Change X; Reduce to ____; Increase to ____

PAR INSP. INTERVAL.: No Change X; Reduce to ____; Increase to ____

REMARKS/RECOMMENDATIONS: Cockpit overhead window supports have been designed per KAC Engineering Order 6-28442 and are being installed on SH-2D Helicopters. Recommend incorporation of supports on all H-2 helicopters. Supports will prevent flexing and subsequent failure.

PRIOR HISTORY: ☐ D & I ☐ U. R. ☐ S. I. R. ☒ Field Rep. Reports ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No. R-983 Page 2-16

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-15	Canted Frame Web	Forward Fuselage	Airframe	1.	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Cracks. Two retractable steps are mounted on the aft face of the web Pilots' seat supports mounted on forward face of the web. Cracks appear as a function of fatigue.

CONTRIBUTING FACTORS: When standing on the canted frame retractable steps, the brackets and web flex and ultimately crack. Loads induced by pilots' seat may also be a factor.

USUAL CORRECTIVE ACTION: Repaired per Structural Repair Manual.

PAR

WUC AREA:	PAR INTVL:	% OF PARS	AVG PAR	PRIMARY FAILURE MODES:
11200/2A	EA.	36	1.4	1. Cracked 2. 3.

DISPOSITION (PERCENT):

REPAIR	REPLACE	TREAT	SCRAP
100	0	0	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.
1121C	Canted Bulkhead	*	☒ SPECIFIC ☐ GENERAL

MTBF 209 MTBR -

MTTR: 0.9 MH/MA 1.0

MH/FH ORG. .005 INT. -

WUC PERCENT OF SYSTEM: MH/FH: 0.7 NORM: - FAILURES: 1.4 NORS: -

FAILURES BY CAUSE:

	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	75.8
COMMON HARDWARE	8.1
ALL OTHER	16.1

FAILURES BY WHEN DISC.

	%
PRE-FLT/IN-FLT (Abort)	1.0
IN-FLT (No Abort)	2.0
PRE-FLT/POST-FLT/DAILY INSP.	8.1
CALENDAR INSP.	23.2
OTHER	65.7

FIVE-HIGH FAILURE CAUSES:

	%
1. Corroded	67.6
2. Cracked	9.5
3. Missing Hdw.	6.7
4. Broken	6.7
5. Adjust. Improp.	3.8
TOTAL FIVE-HIGH	94.3

APPLICABLE PART NUMBERS:

NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change ____
- Reduce to ____
- Increase to each Cal.

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS:

Increase web strength by adding a doubler or suitable angle stiffeners.

* Add to Calendar Inspection MRC:
"Canted Frame and Structure, Steps, Seat Supports".
Strict compliance with corrosion MRC Deck is required.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-18

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-17	Fuel Cell Sump Brackets	Center Fuselage Tub	Airframe	12	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Brackets crack. As a secondary effect, fuel cell sumps shift slightly, causing chafing of sumps internally against fuel quantity probes.

CONTRIBUTING FACTORS: Operational vibration. Brackets material gage too light.

USUAL CORRECTIVE ACTION: Repaired per Structural Repair Manual.

PAR

WUC AREA:	PAR INTVL:	% OF PARS	AVG/PAR	PRIMARY FAILURE MODES:
11400/60	EA.	36	1.4	1. Cracked 2. 3.

DISPOSITION (PERCENT): 54 REPAIR, 38 REPLACE, 8 TREAT, 0 SCRAP

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF	MTTR:	MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		*	☐ SPECIFIC ☐ GENERAL	MTBF ___ MTBR ___	MTTR: ___ MH/MA ___	ORG. ___ INT. ___	MH/FH: ___ NORM: ___ FAILURES: ___ NORS: ___

FAILURES BY CAUSE: %
- MAINT./OPER. ERROR
- WEATHER ENVIRONMENT
- COMMON HARDWARE
- ALL OTHER

FAILURES BY WHEN DISC. %
- PRE-FLT/IN-FLT (Abort)
- IN-FLT (No Abort)
- PRE-FLT/POST-FLT/DAILY INSP.
- CALENDAR INSP.
- OTHER

FIVE-HIGH FAILURE CAUSES: %
1.
2.
3.
4.
5.

TOTAL FIVE-HIGH —

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K679054-37, -38, -39, -43, -45, -47, -49, -54, -56, -57, -58, -77	

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ___
- Increase to ___

PAR INSP. INTERVAL.
- No Change X
- Reduce to ___
- Increase to ___

REMARKS/RECOMMENDATIONS:

Incorporation of increased strength brackets.

* At fuel cell installation.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☒ Other Reports Static Test

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-18	Box Step	Fuselage	Airframe	7	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Steps found corroded, cracked and broken.

CONTRIBUTING FACTORS: Constant use of steps erodes protective finish, & is conducive to wear, bending & cracking of step metal in addition to corrosion.

USUAL CORRECTIVE ACTION: Repaired per Structural Repair Manual.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:
11400/6B 11600/6A	EA.	% OF PARS 88 AVG/PAR 3.3	1. Corroded 2. Cracked, Broken 3.

DISPOSITION (PERCENT):

REPAIR	REPLACE	TREAT	SCRAP
57	0	43	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH
1121Q 1141M 11613	Steps, Fuselage	Cal.	☒ SPECIFIC ☐ GENERAL	MTBF 73.5 MTBR 7142	MTTR: 1.1 MH/MA 1.3	ORG. .018 INT. .005

WUC PERCENT OF SYSTEM: MH/FH: 2.6 NORM: ____ FAILURES 4.1 NORS: ____

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	1.4
WEATHER/ENVIRONMENT	21.3
COMMON HARDWARE	18.8
ALL OTHER	54.4

FAILURES BY WHEN DISC	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	12.1
PRE-FLT/POST-FLT/DAILY INSP.	29.5
CALENDAR INSP.	23.9
OTHER	34.5

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	34.1
2. Cracked	17.9
3. Broken	15.8
4. Missing Hdw.	11.7
5. Worn	2.2
TOTAL FIVE-HIGH	81.7

APPLICABLE PART NUMBERS:

NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
No Change X
Reduce to ____
Increase to ____

PAR INSP. INTERVAL.
No Change X
Reduce to ____
Increase to ____

REMARKS/RECOMMENDATIONS:
1. Change to extruded aluminum alloy edges.
2. Nonskid foot pads - slightly sloped to prevent water accumulation in the box.

PRIOR HISTORY:
- ☐ D & T
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM	LOCATION	SYSTEM	QPA	SOURCE
11-19	Rotor Support Tiedown Fittings	Fuselage	Airframe	8	[X] CFE [ ] GFE

NATURE OF DISCREPANCY: Cracked - this failure has been most often reported following deployment aboard ships subjected to high sea-state conditions.

CONTRIBUTING FACTORS: Receptacle doublers too light. Heavy loads transmitted to the fittings due to heavy ship rolling and pitching.

USUAL CORRECTIVE ACTION: Repaired per Structural Repair Manual.

PAR

WUC/AREA	PAR INTVL.	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES	DISPOSITION (PERCENT)	DISP IS USUALLY
11600/6A 11600/6B	EA.	% OF PARS 28 AVG/PAR 1.7	1. Cracked 2. 3.	50 REPAIR, 50 REPLACE, 0 TREAT, 0 SCRAP	[ ] WITHIN PAR [X] O & A

FIELD HISTORY

WUC	NOMENCLATURE	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM
1161A	Rotor Tiedown Fitting	Cal.*	[X] SPECIFIC [ ] GENERAL	MTBF 470 MTBR -	MTTR: 0.6 ~~0.7~~ MH/MA	ORG. .001 INT. -	MH/FH: 0.2 NORM: - FAILURES: 0.6 NORS: -

FAILURES BY CAUSE	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	59.1
COMMON HARDWARE	15.9
ALL OTHER	25.0

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	-
PRE-FLT/POST-FLT/DAILY INSP.	11.3
CALENDAR INSP.	18.2
OTHER	70.4

FIVE-HIGH FAILURE CAUSES	%
1. Corroded	56.8
2. Missing Hdw.	15.9
3. Missing Part	9.1
4. Loose	4.5
5. Cracked	4.5
TOTAL FIVE-HIGH	90.8

APPLICABLE PART NUMBERS: NUMBER	MTBR

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- [ ] FLIGHT SAFETY
- [X] USEFUL LIFE
- [X] PAR COST
- [X] OPERATING COST

FLEET INSP. INTERVAL.
No Change X
Reduce to ____
Increase to ____

PAR INSP. INTERVAL.
No Change X
Reduce to ____
Increase to ____

REMARKS/RECOMMENDATIONS: Design change to a higher strength receptacle doubler material with added load carrying structure.

* Present insp. refers to receptacle cover only. Requirement should be expanded to include insp. of fitting (Weldment Assy.) for cracks, corrosion.

PRIOR HISTORY:
- [ ] D & I
- [ ] U. R.
- [ ] S. I. R.
- [X] Field Rep. Reports
- [ ] Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-22	Retractable steps	Aft Fuselage	Airframe	3	☒ CFE ☐ GFE

NATURE OF DISCREPANCY:	CONTRIBUTING FACTORS:	USUAL CORRECTIVE ACTION:
Step springs corrode and break.	Springs are inaccessible for corrosion control inspection.	Treated, repaired per Structural Repair Manual & MMI. Springs are inaccessible and time-consuming to replace.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11600/6B 11700	EA.	% OF PARS 20; AVG/PAR 1.2	1. Corroded 2. Broken, Inoperative 3.	0 REPAIR; 67 REPLACE; 33 TREAT; 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
11713	Retractable Steps	Cal.	☒ SPECIFIC ☐ GENERAL	MTBF 233; MTBR 2956	MTTR: 1.1; MH/MA 1.6	ORG. .007; INT. –	MH/FH: 1.1 NORM: –; FAILURES: 1.3 NORS: –

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	1.1
WEATHER/ENVIRONMENT	11.2
COMMON HARDWARE	37.1
ALL OTHER	50.6

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	1.1
IN-FLT (No Abort)	15.7
PRE-FLT/POST-FLT/DAILY INSP.	33.7
CALENDAR INSP.	22.5
OTHER	27.0

FIVE-HIGH FAILURE CAUSES:	%
1. Missing Hdw.	32.6
2. Broken	19.1
3. Loose	15.7
4. Corroded	11.2
5. Adjust./Align.	4.5
TOTAL FIVE-HIGH	83.1

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K632064-3	-
K632064-11	1463
72-028-125-1500	-
72-028-125-1750	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☐ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS:
1. Corrosion inspection per Corrosion MRC. will alleviate problem.
2. Design change to improve spring material and provide better access to springs for replacement.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-24	Tail Pylon Fairing	Pylon Trailing Edge	Airframe	1	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Attaching screws puncture & crack fibreglass fairing. Fairing pulls out of pylon retaining straps thru normal flexing & has been lost in flight

CONTRIBUTING FACTORS: 1. Void between fairing & pylon mounted support bracket causes screws to crush & break thru fairing. 2. Support brackets are not of sufficient strength. 3. Fairing retention straps are too narrow. 4. Installation instructions not followed by maintenance personnel.

USUAL CORRECTIVE ACTION: Repaired or replaced per Structural Repair Manual, KAC E.O. 6-27169 (Drawing K632701) & MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT): REPAIR	REPLACE	TREAT	SCRAP	DISP IS USUALLY:
11700	EA.	% OF PARS 32 AVG/PAR 1.3	1. Gouged, Punctured 2. Cracked 3.	100	0	0	0	☐ WITHIN PAR ☒ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
1171B	Trailing Fairing	Daily Cal.	☒ SPECIFIC ☐ GENERAL	MTBF 450 10347 MTBR —	MTTR: 1.6 MH/MA 2.2	ORG. .005 INT. -	MH/FH: .7 NORM: 3.2 FAILURES: .7 NORS: 7.4

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	15.2
COMMON HARDWARE	30.4
ALL OTHER	54.3

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	19.6
PRE-FLT/POST-FLT/DAILY INSP.	19.5
CALENDAR INSP.	23.9
OTHER	37.0

FIVE-HIGH FAILURE CAUSES:	%
1. Missing, Hardware	23.9
2. Cracked	17.4
3. Corroded	13.0
4. Missing Part	13.0
5. Broken	8.7
TOTAL FIVE-HIGH	76.0

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K632701-65	8412

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☒ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: A request to submit an ECP for improved fairing retention, submitted in March, 1971, has not been acted upon to date. This change would provide wider retention straps, increased strength support brackets & wood filler blocks between the fairing & bracket. (Blocks are being incorporated via E.O. 6-27169 at PAR in the interim) Strict compliance with installation instructions in MMI will also reduce failure potential.

PRIOR HISTORY:
- ☐ D & I
- ☒ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

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STATEMENT OF PROBLEM

ITEM NO.	ITEM	LOCATION	SYSTEM	QPA	SOURCE
11-25	External Power Receptacle	Right-Hand Side of Forward Fuselage.	Airframe	1	[X] CFE [ ] GFE

NATURE OF DISCREPANCY	CONTRIBUTING FACTORS	USUAL CORRECTIVE ACTION
Corroded	Exposed location & failure to accomplish corrosion control inspection.	Cleaned and treated per Structural Repair Manual.

PAR

WUC/AREA	PAR INTVL.	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES	DISPOSITION (PERCENT)	DISP IS USUALLY
11200/6A	EA.	% OF PARS 16 AVG/PAR 1.5	1. Corroded 2. 3.	50 REPAIR 17 REPLACE 33 TREAT 0 SCRAP	[X] WITHIN PAR [ ] O & A

FIELD HISTORY

WUC	NOMENCLATURE	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM
4211G	External Power Receptacle	Cal.	[X] SPECIFIC [ ] GENERAL	MTBF 647 MTBR -	MTTR: 1.9 MH/MA 2.9	ORG. .005 INT. -	MH/FH: 1.5 NORM: 11.1 FAILURES: 1.8 NORS: 0.7

FAILURES BY CAUSE	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	37.5
COMMON HARDWARE	6.3
ALL OTHER	56.3

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	3.1
IN-FLT (No Abort)	15.6
PRE-FLT/POST-FLT/DAILY INSP.	37.5
CALENDAR INSP.	18.8
OTHER	25.0

FIVE-HIGH FAILURE CAUSES	%
1. Corroded	28.1
2. Loose	25.0
3. Broken	9.4
4. Cracked	6.3
5. Dirty	6.3
TOTAL FIVE-HIGH	75.0

APPLICABLE PART NUMBERS:

NUMBER	MTBR
AN 3114-1B	33649
K631105-173	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY:
- [ ] FLIGHT SAFETY
- [X] USEFUL LIFE
- [X] PAR COST
- [X] OPERATING COST

FLEET INSP. INTERVAL.
- No Change ____
- Reduce to ____
- Increase to X

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS:
1. Compliance with corrosion MRC Deck (currently being Fleet service tested) will alleviate corrosion problem thru early detection & treatment.
2. Improved corrosion resistant surface finish is required.

PRIOR HISTORY:
- [ ] D & I
- [ ] U. R.
- [ ] S. I. R.
- [X] Field Rep. Reports
- [ ] Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

Report No. R-983 Page 2-27

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-26	Aux. Fuel Tank Supports	R.H. & L.H. Center Fuselage	Airframe	2	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Adjustable CAM-LOC fasteners in the access cover over the bomb shackle corrode, break (springs) and are very time consuming to operate. Sway braces are also time-consuming to adjust when replacing external stores.

CONTRIBUTING FACTORS: 1. Adjustable CAM-LOC'S are impractical for this application. 2. Failure to accomplish corrosion control inspection. 3. Dual jam nuts on sway brace studs are inherently time-consuming to adjust.

USUAL CORRECTIVE ACTION:
1. Fasteners replaced, corrosion cleaned & treated per Structural Repair Manual.
2. CAM-LOKS and sway braces adjust per MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
No PAR Data		% OF PARS ___ AVG/PAR ___	1. 2. 3.	REPAIR REPLACE TREAT SCRAP	☐ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
4611K	Auxiliary Tank Support	Cal.	☒ SPECIFIC ☐ GENERAL	MTBF 158, MTBR 10347	MTTR: 0.9, MH/MA 1.0	ORG. .006, INT. -	MH/FH: 1.9, NORM: -, FAILURES: 5.4, NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	53.4
COMMON HARDWARE	8.4
ALL OTHER	38.2

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	11.5
PRE-FLT/POST-FLT/DAILY INSP.	16.0
CALENDAR INSP.	19.8
OTHER	52.7

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	53.4
2. Cracked	16.8
3. Adjst/Align Impr.	6.1
4. Loose	4.6
5. Missing Hardware	3.8
TOTAL FIVE-HIGH	84.7

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K631402-1	-
K631402-2	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☐ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ___
- Increase to ___

PAR INSP. INTERVAL.
- No Change X
- Reduce to ___
- Increase to ___

REMARKS/RECOMMENDATIONS: 1. Replace bomb shackle access cover adjustable CAM-LOC fasteners with a minimum number of standard hex head bolts. ECP 357 includes this improvement.
2. Change sway brace design to employ single jam nut on stud (by threading stud into support for example). 3. Strict compliance with Corrosion Control MRC Deck.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-28

STATEMENT OF PROBLEM

ITEM NO.	ITEM	LOCATION	SYSTEM	QPA	SOURCE
11-27	Jettison Cable, Aux Fuel Tanks	Landing Gear Wheel Wells	Airframe	2	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Cables become frayed and broken through due to handling damage and exposure to airborne debris.

CONTRIBUTING FACTORS: Exposed cables in wheel wells are susceptible to handling damage & to potential damage caused by debris thrown off main landing gear wheels.

USUAL CORRECTIVE ACTION: Replaced per the MMI.

PAR

WUC/AREA	PAR INTVL	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES	DISPOSITION (PERCENT)	DISP IS USUALLY
11400/6A 11400/6B	EA.	% of PARS 16 AVG/PAR 1.0	1. Broken 2. Frayed 3.	REPAIR 0, REPLACE 100, TREAT 0, SCRAP 0	☐ WITHIN PAR ☒ O & A

FIELD HISTORY

WUC	NOMENCLATURE	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM
4614A	Aux Tanks Jettison Control	Cal.	☐ SPECIFIC ☒ GENERAL	MTBF 559 MTBR -	MTTR: 0.4 MH/MA 0.5	ORG. .001 INT. -	MH/FH: 0.3 NORM: - FAILURES: 0.7 NORS: -

FAILURES BY CAUSE	%
MAINT./OPER. ERROR	8.1
WEATHER/ENVIRONMENT	18.9
COMMON HARDWARE	43.2
ALL OTHER	29.8

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	2.7
IN-FLT (No Abort)	29.7
PRE-FLT/POST-FLT/DAILY INSP.	24.3
CALENDAR INSP.	18.9
OTHER	24.3

FIVE-HIGH FAILURE CAUSES	%
1. Broken Safety Wire	33.3
2. Broken	16.7
3. Corroded	16.7
4. Adjust. Improp.	11.1
5. Binding/Stuck	11.1
TOTAL FIVE-HIGH	88.9

APPLICABLE PART NUMBERS:

NUMBER	MTBR
NAS 302R37-201	-
NAS 302R37-275	-
K656046-1	-
K656046-11	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY:
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Recommend design change to provide protective covers or shields for the cable.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY – H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
11-28	Boot-Aux Tank Jettison Cable	Wheel wells - 4 each. Aus. tank supports - 2 ea.	Airframe	6	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Boots become deteriorated, unbonded & torn as a result of exposure to the elements.

CONTRIBUTING FACTORS: Rubber is susceptible to deterioration.

USUAL CORRECTIVE ACTION: Replaced per MM1.

PAR

WUC/AREA:	PAR INTVL:		PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11400/6A 11400/6B	EA.	% OF PARS 56 AVG/PAR 1.1	1. Unbonded 2. Torn 3.	REPAIR 50, REPLACE 50, TREAT 0, SCRAP 0	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.			MH/FH	WUC PERCENT OF SYSTEM:
4614A	Aux. Tank Jettison Control	Cal.	☐ SPECIFIC ☒ GENERAL	MTBF 559 MTBR -	MTTR 9.4 MH/MA 0.5	ORG. .001 INT. -	MH/FH: 0.3 NORM: - FAILURES: 0.7 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	8.1
WEATHER/ENVIRONMENT	18.9
COMMON HARDWARE	43.2
ALL OTHER	29.8

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	2.7
IN-FLT (No Abort)	29.7
PRE-FLT/POST-FLT/DAILY INSP.	24.3
CALENDAR INSP.	18.9
OTHER	24.3

FIVE-HIGH FAILURE CAUSES:	%
1. Broken Safety Wire	33.3
2. Broken	16.7
3. Corroded	16.7
4. Ajust. Improp.	11.1
5. Binding/Stuck	11.1
TOTAL FIVE-HIGH	88.9

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K656013-11	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Change to a boot material more resistant to deterioration.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

Report No. R-983 Page 2-30

STATEMENT OF PROBLEM

ITEM NO.: 12-1

ITEM: Glare Shield

LOCATION: Cockpit (Instrument Panel)

SYSTEM: Fuselage Compartments

QPA: 1

SOURCE: ☒ CFE ☐ GFE

NATURE OF DISCREPANCY: The glare shields crack at random locations. Corrosion occurs at the attach brackets.

CONTRIBUTING FACTORS: Glare Shield material is ROYALITE (plastic). Cracks occur as a result of exposure to sun, time and normal vibration.

USUAL CORRECTIVE ACTION: Repaired or replaced per Structural Repair Manual & MMI.

PAR

WUC/AREA: 11200/2A, 11200/2B

PAR INTVL: EA.

% OF PARS 28

AVG/PAR 1.7

PRIMARY FAILURE MODES:
1. Cracked
2.
3.

DISPOSITION (PERCENT):

REPAIR	REPLACE	TREAT	SCRAP
92	8	0	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC: 12111

NOMENCLATURE: Glare Shield

INSP. INTVL.: *

DATA APPL.: ☒ SPECIFIC ☐ GENERAL

MTBF 575

MTBR 20693

MTTR: 0.9

MH/MA 1.3

MH/FH ORG. .002

INT. -

WUC PERCENT OF SYSTEM:

MH/FH: 2.4 NORM: 24.0

FAILURES: 3.0 NORS: 98.0

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	-
WEATHER/ENVIRONMENT	69.4
COMMON HARDWARE	8.3
ALL OTHER	22.2

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	-
IN-FLT (No Abort)	8.3
PRE-FLT/POST-FLT/DAILY INSP.	19.4
CALENDAR INSP.	13.9
OTHER	58.3

FIVE-HIGH FAILURE CAUSES:	%
1. Corroded	63.9
2. Cracked	13.9
3. Missing Hardware	5.6
4. Dirty	5.6
5. Loose/Damaged Hdwr.	2.8
TOTAL FIVE-HIGH	91.8

APPLICABLE PART NUMBERS:

NUMBER	MTBR
K686030-1	-
K686030-5	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☒ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change ____
- Reduce to ____
- Increase to ea. Cal.

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Design change to metal or a fibreglass composition which will be less susceptible to failure.

* Inspection of glare shield & instrument panel is not now specifically required. These requirements should be added to the calendar inspection. Strict compliance with corrosion MRC Deck is required.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

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STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
12-5	Heat/Defog Tubes & Insulation	Cockpit & Cabin	Miscellaneous Utilities	7	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: The aluminum insulation wrapped around heat/defog tubes in the cockpit & cabin is frequently found torn, cut & chafed. At times, the tubes themselves are found improperly positioned or broken.

CONTRIBUTING FACTORS: Personnel entering the cockpit often grip the vertical defog tubes located just inside & forward of the pilot and copilots doors. Heat tubes in the aft cabins are used as hand holds or struck by cargo when cabin accoustical panels are not installed.

USUAL CORRECTIVE ACTION: Replaced per MMI.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11200/2A 11200/2B 11400/4A	EA.	% OF PARS 52 AVG/PAR 3.0	1. Torn, Cut 2. Worn, Chafed, Deteriorated 3. Broken, Damaged	REPAIR 74 REPLACE 26 TREAT 0 SCRAP 0	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.	MTBF / MTBR	MTTR / MH/MA	MH/FH	WUC PERCENT OF SYSTEM:
49511	Tubes/Hoses	C	☒ SPECIFIC ☐ GENERAL	MTBF 647 MTBR -	MTTR: 0.8 MH/MA 0.9	ORG. .001 INT. -	MH/FH: 0.7 NORM: 0.2 FAILURES: 2.0 NORS: -

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	18.8
WEATHER/ENVIRONMENT	12.5
COMMON HARDWARE	12.5
ALL OTHER	56.3

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	9.4
IN-FLT (No Abort)	3.1
PRE-FLT/POST-FLT/DAILY INSP.	25.0
CALENDAR INSP.	12.5
OTHER	50.0

FIVE-HIGH FAILURE CAUSES:	%
1. Worn, Chafed, Frayed	18.8
2. Impr. Pstnd/Slctd	12.5
3. Missing Hardware	12.5
4. Broken	9.4
5. Loose	9.4
TOTAL FIVE-HIGH	62.6

APPLICABLE PART NUMBERS: NUMBER	MTBR
BL15460-1	-
FT2531-7-128	-
K686005-101	-
K686038-47	-
K686725-16	-
K686725-18	-
K686725-19	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS:
1. Add a protective guard to cockpit de-fog tubes.
2. Add a durable outer sheathing to heater tubes in aft cabin.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☒ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

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STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
12-6	Plotting Board Bracket	Cockpit	Furnishings	1 assy.	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: The bracket, which secures the plotting board in the cockpit, frequently cracks, and corrodes, and the rubber stop becomes unbonded and loose. Strap tears.

CONTRIBUTING FACTORS: The plotting board is secured against the cockpit ceiling behind the copilot's head. It is usually removed and replaced by feel. During removal and replacement, the bracket often bends and ultimately cracks.

USUAL CORRECTIVE ACTION: Replaced or repaired per Structural Repair Manual.

PAR

WUC/AREA:	PAR INTVL:	% OF PARS	AVG/PAR	PRIMARY FAILURE MODES:
11200/2B	EA.	40	1.4	1. Corroded 2. Unbonded Loose 3. Broken

DISPOSITION (PERCENT): REPAIR	REPLACE	TREAT	SCRAP
36	64	0	0

DISP IS USUALLY: ☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.			MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		*	☐ SPECIFIC ☐ GENERAL	MTBF ___ MTBR ___	MTTR: ___ MH/MA ___	ORG. ___ INT. ___	MH/FH: ___ NORM: ___ FAILURES: ___ NORS: ___

FAILURES BY CAUSE:	%
MAINT./OPER. ERROR	
WEATHER/ENVIRONMENT	
COMMON HARDWARE	
ALL OTHER	

FAILURES BY WHEN DISC.	%
PRE-FLT/IN-FLT (Abort)	
IN-FLT (No Abort)	
PRE-FLT/POST-FLT/DAILY INSP.	
CALENDAR INSP.	
OTHER	

FIVE-HIGH FAILURE CAUSES:	%
1.	
2.	
3.	
4.	
5.	
TOTAL FIVE-HIGH	—

APPLICABLE PART NUMBERS: NUMBER	MTBR
K686027-1	-
K686045-1	-

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☒ OPERATING COST

FLEET INSP. INTERVAL.
- No Change ___
- Reduce to ___
- Increase to ea. Cal.

PAR INSP. INTERVAL.
- No Change X
- Reduce to ___
- Increase to ___

REMARKS/RECOMMENDATIONS:
1. Corrosion control measures per Corrosion Inspection MRC's.
2. Redesign bracket of a heavier gage material in accordance with Human Engineering precepts relative to plotting board removal and re-installation by feel. Delete use of bonded rubber stops.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☐ Other

DATA SURVEY SUMMARY - H-2 ARP PROGRAM

STATEMENT OF PROBLEM

ITEM NO.	ITEM:	LOCATION:	SYSTEM:	QPA:	SOURCE:
14-3	Pedal-Pad	Cockpit Directional Control Pedals	Flight Controls	4	☒ CFE ☐ GFE

NATURE OF DISCREPANCY: Antiskid pads bonded to the directional control pedals become unbonded and torn.

CONTRIBUTING FACTORS: Occurs as a result of continuous scuffing by pilot's and co-pilot's shoes.

USUAL CORRECTIVE ACTION: Replaced per MMI.

PAR

WUC AREA:	PAR INTVL:	% OF PARS / AVG/PAR	PRIMARY FAILURE MODES:	DISPOSITION (PERCENT):	DISP IS USUALLY:
11200/2A 11200/2B	EA.	% OF PARS 68 AVG/PAR 2.6	1. Unbonded, Loose 2. Torn 3.	73 REPAIR / 27 REPLACE / 0 TREAT / 0 SCRAP	☒ WITHIN PAR ☐ O & A

FIELD HISTORY

WUC:	NOMENCLATURE:	INSP. INTVL.	DATA APPL.			MH/FH	WUC PERCENT OF SYSTEM:
NO APPLICABLE WORK UNIT CODE		Cal.	☐ SPECIFIC ☐ GENERAL	MTBF — MTBR —	MTTR: — MH/MA —	ORG. — INT. —	MH/FH: ____ NORM: ____ FAILURES: ____ NORS: ____

FAILURES BY CAUSE:	%	FAILURES BY WHEN DISC.	%	FIVE-HIGH FAILURE CAUSES:	%	APPLICABLE PART NUMBERS: NUMBER	MTBR
MAINT./OPER. ERROR		PRE-FLT/IN-FLT (Abort)		1.		K653016-5,-6	—
WEATHER/ENVIRONMENT		IN-FLT (No Abort)		2.		K653017-15,-16	—
COMMON HARDWARE		PRE-FLT/POST-FLT/DAILY INSP.		3.		K653062-13,-14	—
ALL OTHER		CALENDAR INSP.		4.			
		OTHER		5.			
				TOTAL FIVE-HIGH	—		

RECOMMENDATIONS

IMPROVEMENT CATAGORY
- ☐ FLIGHT SAFETY
- ☒ USEFUL LIFE
- ☐ PAR COST
- ☐ OPERATING COST

FLEET INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

PAR INSP. INTERVAL.
- No Change X
- Reduce to ____
- Increase to ____

REMARKS/RECOMMENDATIONS: Redesign pedals to incorporate a non-skid metal integral foot pad.

PRIOR HISTORY:
- ☐ D & I
- ☐ U. R.
- ☐ S. I. R.
- ☐ Field Rep. Reports
- ☐ Other